STANDARD WIRING

FOR

ELECTRIC LIGHT AND POWER

CUSHING.

1915

21ST YEAR. 1915 21ST EDITION

STANDARD WIRING

FOR

ELECTRIC LIGHT AND POWER

AS ADOPTED BY

THE FIRE UNDERWRITERS

OF THE UNITED STATES

IN ACCORDANCE WITH THE NATIONAL ELECTRICAL CODE, WITH EXPLANATIONS, ILLUSTRATIONS AND TABLES NECESSARY FOR OUTSIDE AND INSIDE WIRING AND CONSTRUCTION FOR ALL SYSTEMS, TOGETHER WITH A SECTION ON HOUSE WIRING.

BY

H. C. CUSHING, JR.
Fellow Am. Inst. Elecl. Engrs.

WITH THE CO-OPERATION OF THE NATIONAL ELECTRIC LIGHT ASSOCIATION COMMITTEE ON WIRING EXISTING BUILDINGS, AND THE SOCIETY FOR ELECTRICAL DEVELOPMENT.

INDEX TO CONTENTS—PAGE 216

PUBLISHED BY
H. C. CUSHING, JR., PULITZER BLDG., NEW YORK,
U. S. A.

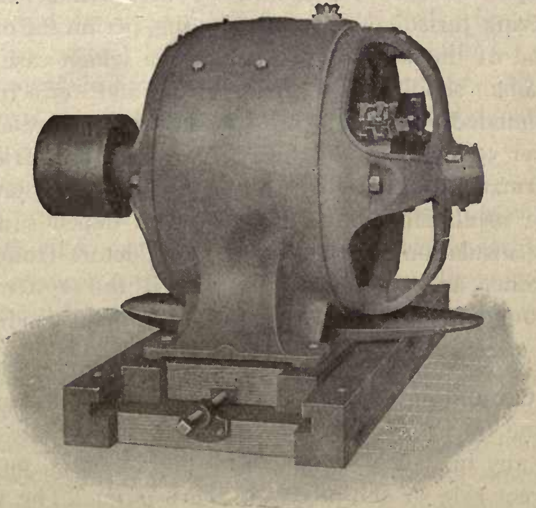
1915

PREFACE

THE Author, with the collaboration of Mr. F. E. Cabot, Chairman of the Electrical Committee of the National Fire Protection Association, and with the co-operation of the National Electric Light Association Committee on Wiring Existing Buildings, and the Society for Electrical Development, has made it his aim in compiling the following pages to set forth, as clearly as possible, the essential rules and requirements for safe and economical exterior and interior wiring and construction, the object being to standardize, as much as possible, all work of this nature and to respectfully suggest to the Electrical Engineer, Architect, House-owner, Contractor and Wireman just what is required by Fire Underwriters Inspectors throughout the United States.

THE GENERATOR

All generators, whether for central station or isolated lighting or power work, should be located in a dry place so situated that the surrounding atmosphere is cool. If the surrounding air is warm it reduces the safe carrying capacity of the machine, and is likely to allow such temperatures to



Proper installation of dynamo or motor on filled wooden base frame.

rise in the machine itself as to burn out either armature or field, or both. A generator should not be installed in any place where any hazardous process is carried on, nor in places where they would be exposed to inflammable gases or flying combustible materials, as the liability of occasional sparks from the commutator or brushes might cause more or less serious explosions.

Foundations. Wherever it is possible, generators should be raised or insulated above the surrounding floor on wooden base frames, which should be kept filled to prevent the absorption of moisture, and also kept clean and dry. When it is impracticable to insulate a generator on account of its great weight or any other reason, the Inspection Department of the Board of Fire Underwriters having jurisdiction may, in writing, permit the omission of the wooden base frame, in which case the frame should be permanently and effectively grounded. Generators operating at a potential of over 550 volts should always have their base frames permanently grounded. When a frame is grounded the insulation of the entire system depends upon the insulation of the generator conductors from the frame, and if this breaks down the system is grounded and should be put in proper condition at once.

Grounding Generator Frames can be effectually done by firmly attaching a wire to the frame and to any main water pipe inside the building, on the street side of the meter, if there is one. The wire should be securely fastened to the pipe by screwing a brass plug into the pipe and soldering the wire to this plug or by approved ground clamps. When the generator is direct driven an excellent ground is attained through the engine coupling and piping.

Wherever high voltage machines have their frames grounded a small board walk should be built around them and raised above the floor on porcelain or glass insulators, in order that the at-

tendant may be protected from shock when adjusting brushes or working about the machine.

Accessibility. Sufficient space should be left on all sides of the generator, or motor, and especially at the commutator end, so that there may be ample room for removing armatures, commutators, or other parts at any time.

Circuit Breakers and Fuses. Every constant potential generator should be protected from excessive current by a fuse, or equivalent device of approved design, such as a circuit breaker. Such devices should be placed on or as near the dynamo as possible.

For two-wire, direct-current generators, single pole protection will be considered as satisfying the above rule, provided the safety device is located and connected that the means for opening same is actuated by the *entire* generator current thus completely opening the generator circuit.

When two-wire, direct-current generators are used in conjunction with balancer sets to obtain a neutral for three-wire systems, a protective device should be installed which will operate and disconnect the three-wire system should an excessive unbalancing of voltage occur. If a generator, not electrically driven, in a two-wire system has one terminal grounded, the circuit breaker above mentioned should be placed in the grounded lead.

For three-wire direct-current generators, either compound or shunt wound, a safety device should be placed in each armature lead of sufficient capacity and so arranged as to take care of the entire current from the armature.

The safety devices for this service should be a double-pole, double-coil overload circuit-breaker, or a four-pole circuit-breaker connected in the main and equalizer leads and tripped by means of two overload devices, one in each armature lead. The safety devices thus required should be so interlocked that no one pole can be opened without simultaneously disconnecting both sides of the armature from the system.

Fuses should never be used for this class of protection.

In general, generators should preferably have no exposed live parts and the leads should be well insulated and thoroughly protected against mechanical injury. This protection of the bare live parts against accidental contact would apply also to all exposed, uninsulated conductors outside of the generator and not on the switchboard.

Waterproof Covers, though not required, should be provided for every generator and motor and placed over each machine as soon as it is shut down. Negligence in this matter has caused many an armature or field coil to burn out, as only a few drops of water are necessary to cause a short circuit, when the machine is started up again, that might do many dollars' worth of damage, to say nothing of the inconvenience of having to shut off light or power when it is most needed, and for an indefinite length of time.

Name Plates. Every generator and motor should be provided with a name plate, giving the maker's name, the capacity in volts and amperes and normal speed in revolutions per minute. This will

show exactly what the machine is designed for, and how it should be run.

Terminal blocks when used on generators should be made of *approved* non-combustible non-absorptive, insulating material, such as slate, marble or porcelain.

Wiring from Generators to switchboards and thence to outside lines should be in plain sight or readily accessible, and should be supported entirely throughout upon non-combustible insulators (such as glass or porcelain) and in no case should any wire come in contact with anything except these insulators, and the terminals upon the generators and switchboard. When it becomes necessary to run these wires through a wall or floor, the holes should be protected by some approved non-combustible insulating tube, such as glass or porcelain, and in every case the tube should be so fastened that it shall not slip or pull out. Sections of any conduit, whether armored or otherwise, that are chopped off for this purpose, should not be used. All wires for generator and switchboard work should be kept so far apart that there is no liability of their coming in contact with one another, nor of short circuit from metallic tools used about them. All wire used in this class of work should be the best quality of "rubber covered" (see page 66). Bus-bars on switchboards, may be made of bare metal, so that additional circuits may be readily attached. They should have ample carrying capacity, so as not to heat with the maximum current likely to flow through them under natural conditions. (See "Capacity of Wire Table," page 81.)

So much trouble in past years has arisen from faulty construction of switchboards, and the apparatus placed upon them, that strict requirements have been necessarily adopted by engineers as well as insurance inspectors, and the following suggestions are recommended by the latter; although it is advisable, when possible, that all wires from generators to switchboards be in plain sight and readily accessible, wires from generator to switchboard may, however, be placed in a conduit in the brick or cement pier on which the generator stands, provided that proper precautions are taken to protect them against moisture and to thoroughly insulate them from the pier or foundation. If lead-covered cable is used, no further protection will be required, but it should not be allowed to rest upon sharp edges which in time might cut into the lead sheath, especially if the cables were liable to vibration. A smooth runway is desired. If iron conduit is provided, double braided rubber-covered wire will be satisfactory. In wiring switchboards with regard to their ground detectors, voltmeters, pilot lights, potential transformers or other indicating instruments. Nothing smaller than No. 14 B. & S. gage "rubber covered" wire should be used, and no such circuit should carry over 660 watts. Such circuits should be protected by *approved* enclosed fuses. (See p. 124.)

The Switchboard should be so placed as to reduce to a minimum the danger of communicating fire to adjacent combustible material, and, like the generator, should be erected in a dry place and kept free from moisture. It is necessary that it should

be accessible from all sides when the wiring is done on the back of the board, but may be placed against a brick, stone or cement wall when all wiring is on the face of the switchboard.

The board should be constructed wholly of non-combustible material and never built up to the ceiling; a space of three feet, at least, should separate the top of the board from the ceiling and at least eighteen inches should separate the wall from the instruments or connections, when the wiring is done on the back of the board. Every instrument, switch or apparatus of any kind placed upon the switchboard should have its own non-combustible insulating base. This is required of every piece of apparatus connected in any way with any circuit. If it is found impossible to place the resistance box, rheostat, or regulator, which should, in every case, be made entirely of non-combustible material, upon the switchboard, it should be placed at least one foot from combustible material or separated therefrom by a non-inflammable, non-absorptive insulating material. This will require the use of a slab or panel of non-combustible, non-absorptive insulating material such as slate, soapstone or marble, somewhat larger than the rheostat, which should be secured in position independently of the rheostat supports. Bolts for supporting the rheostat should be countersunk at least 1/8 inch below the surface at the back of the slab and the holes over the heads of the bolts filled with insulating material. For proper mechanical strength, the slab should be of a thickness consistent with the size and weight of the rheostat, and in no case to be less than 1/2 inch.

If resistance devices are installed in rooms where dust or combustible flyings would be libale to accumulate on them, they should be equipped with dust-proof face plates. Where protective resistances are necessary in connection with automatic rheostats, incandescent lamps may be used, provided that they do not carry or control the main current nor constitute the regulating resistance of the device.

When so used, lamps should be mounted in porcelain receptacles upon non-combustible supports, and should be so arranged that they cannot have impressed upon them a voltage greater than that for which they are rated. They should in all cases be provided with a name-plate, which should be permanently attached beside the porcelain receptacle or receptacles and stamped with the candle-power and voltage of the lamp or lamps to be used in each receptacle.

Wherever insulated wire is used for connection between resistances and the contact device of a rheostat, the insulation should be "slow burning." (See page 67.) For large rheostats and similar resistances, where the contact devices are not mounted upon them, the connecting wires may be run together in groups so arranged that the maximum difference of potential between any two wires in any group shall not exceed 75 volts. Each group of wires should either be mounted on no-combustible, non-absorptive insulators giving at least ½ inch separation from surface wired over, or, where it is necessary to protect the wires from mechanical injury or moisture, be run in *approved* conduit or equivalent. Special attention is again called to the

fact that switchboards should not be built down to the floor, nor up to the ceiling, but a space of at least ten or twelve inches should be left between the floor and the board, and thirty-six inches between the ceiling and the board, when possible, in order to prevent possible fire from communicating from the switchboard to the ceiling, and also to prevent the forming of a partially concealed space very liable to be used for storage of rubbish and oily waste. Where floor is of brick, stone or concrete, the switchboard may go to the floor, but for cleanliness and safety space should always be provided when possible.

Lightning Arresters should be attached to each wire of every overhead circuit connected with the station.

It is recommended to all electric light and power companies that arresters be connected at intervals over systems in such numbers and so located as to prevent ordinary discharges entering (over the wires) buildings connected to the lines (see p. 48).

Arresters for Stations and Sub-stations should be located in readily accessible places away from combustible materials, and as near as practicable to the point where the wires enter the building.

Station arresters are often placed in plain sight on the switchboard. The switchboard, however, does not necessarily afford the only location meeting these requirements. In fact, if the arresters can be located in a safe and accessible place away from the board, this should be done, for, in case the arrester should fail or be seriously damaged there

would then be no chance of starting arcs on the board.

Fire Extinguishers. At least one, or more if the size of the installation demands it, good approved extinguisher should be in plain sight and readily accessible, one which is capable of extinguishing electrical fires or arcs without danger of transmitting a shock to the operator (see page 194).

In all cases, kinks, coils and sharp bends in the wires between the arresters and the outdoor lines should be avoided as far as possible.

They should be connected with a thoroughly good and permanent ground connection by metallic strips or wires having a conductivity not less than that of a No. 6 B. & S. copper wire, and these should be run as nearly in a straight line as possible from the arresters to the earth connection.

Ground wires from lightning arresters should not be attached to gas-pipes within the buildings.

It is often desirable to introduce a choke coil in circuit between the arresters and the dynamo. In no case should the ground wire from a lightning arrester be put into iron pipes, as these would tend to impede the discharge.

Unless a good damp ground is used in connection with all lightning arresters, they are little better than useless. Ground connections should be of the most approved construction, and should be made where permanently damp earth can be conveniently reached. For a bank of arresters such as is commonly found in a power house, the following instructions will be found valuable: First, dig a hole six feet square directly under the arresters until

permanently damp earth has been reached; second, cover the bottom of this hole with two feet of crushed coke or charcoal (about pea-size); third, over this lay 25 square feet of No. 16 copper plate; fourth, solder at least two ground wires, which should not be smaller than No. 4, securely across the entire surface of the ground plate; fifth, now cover the ground plate with two feet of crushed coke or charcoal; sixth, fill in the hole with earth, using running water to settle.

A practical and effective method of installing an outside line arrester is shown on page 48.

All lightning arresters should be mounted on non-combustible bases, and be so constructed as not to maintain an arc after the discharge has passed.

Testing of Insulation Resistance. All circuits except such as are permanently grounded, as described on pages 45 and 46, should be provided with reliable ground detectors. Detectors which indicate continuously and give an instant and permanent indication of a ground are preferable. Ground wires from detectors should not be attached to gas pipes within the building.

Where continuously indicating detectors are not used, the circuits should be tested at least once per day (see page 65), and preferably oftener.

Data obtained from all tests should be recorded and preserved for examination.

Storage or Secondary Batteries should be installed with as much care as generators, and in wiring to and from them the same precautions and rules should be adopted for safety and the prevention of leaks. The room in which they are placed

should not only be kept dry, but exceptionally well ventilated, to carry off all fumes which are bound to arise. The insulators for the support of the secondary batteries should be glass or porcelain, as filled wood alone would not be approved. The use of any metal liable to corrosion should be avoided in cell connections of secondary batteries of the lead or sulphuric acid type.

Care of Generators. A few suggestions as to the care of the generator, as well as its installation, may be of value, and one of the important points under this head is that the driving power should have characteristics of steadiness and regularity of speed, and should always be sufficient to drive the generator with its full load, in additions to the other work which it may be called upon to sustain. Unsatisfactory results are always obtained if attempting to run a generator on an engine operating anything other than its own generator or generators.

Wooden bed plates are supplied, when ordered, for all generators, except in the larger or direct-connected machines.

Most belt-driven generators and motors are fitted with a ratchet or screw bolt, so that they may be moved backward or forward on the bed plate in a direction at right angles to the armature shaft. By this means the driving belt may be tightened or loosened at will while the machine is in operation. Care should be taken in tightening the belt not to bind the bearings of the armature and force the oil from between the surface of the shaft and boxes.

Such practice will inevitably cause heating of the bearings and consequent injury.

Generators are usually assembled, unless ordered otherwise, so that the armature revolves from left to right when the observer faces the pulley end of the shaft. All generators, however, may be driven in either direction by reversing the brush leads and changing field connections.

The generator, if belt driven, is provided with a pulley of the proper size to take care of the power necessary to drive it, and one of different size should not be substituted unless approval be obtained from the generator makers.

When driving from a countershaft which, at best, is bad practice, or when belted directly to the main shaft, a loose pulley or belt holder should be used, to admit of starting and stopping the generator while the shafting is running.

Belts. A thin double or heavy single belt should be used, about a half-inch narrower than the face of the pulley on the generator. An endless belt, one without lacing, gives the greatest steadiness to the lights. For proper length of belts see formula on page 213.

All Bolts and nuts should be firmly screwed down. All nuts which form part of electrical connections should receive special attention.

When copper commutator brushes are used, although now almost obsolete, they are carefully ground to fit the commutator, and they should be set in the holders so as to bear evenly upon its surface.

On machines where two or more copper brushes

are supported on one spindle, the brushes on the same side of the commutator must be set so that they touch the same segments in the same manner. The brushes on the other side of the commutator must be set so as to bear on the segments diametrically opposite. When the brushes are not so set it is impossible to run the machine without sparking. A convenient method of determining the proper bearing point for the brushes, is to set the toe of one brush at the line of insulation, dividing two segments to the commutator; then count the dividing lines for one-half the way around the surface, and set the other brush or brushes at the line diametrically opposite the first. Thus, on a forty-four segment commutator, after setting the tip of one brush at a line of insulation, count around twenty-three lines, setting the other brush at the twenty-third line, thus bringing the tips directly opposite each other. The angle which the brushes form with the surface of the commutator should be carefully noted, and the brushes should not be allowed to wear, so as to increase or decrease this angle. Careless handling of the machine is at once indicated by the brushes being worn either to a nearly square end or to a long taper, in which the forward wires of the brush far outrun the back or inside wires. Either condition cannot fail to be attended with excessive wear of both commutator and brushes.

After copper brushes are set in contact with the commutator, the armature should never be rotated backward. If it is required to turn the armature back, raise the brushes from the commutator by the

thumb screw on the holder provided for that purpose, before allowing such rotation.

Carbon Brushes are now almost universally used and require little or no adjustment or care other than keeping them clean.

Bearings. See that the bearings of the machine are clean and free from grit, and that the oil reservoirs are filled with a good quality of lubricating oil.

The Oil Reservoirs should always be axamined before starting, and all loose grit removed. The oil should all be drawn off at the end of each day's run for the first three or four days and filtered, after which it can be assumed that any grit has been carried off with the filtration, and it will only be necessary to add a little fresh oil once in seven to ten days. These instructions apply only to machines using loose ring oilers attached to each end of the armature shaft.

In starting up a Generator or motor fill the oil reservoirs and see that the oiling rings are free to move. In the case of generators fitted with oil cups, start the oil running at a moderate rate. Too little oil will result in heating and injury of the bearing; but, on the other hand, excessive lubrication is unnecessary, wasteful, and sometimes productive of harm.

When the generator is ready to be started, place the driving belt on the pulley on the armature shaft, and then slip it from the loose pulley or belt holder on to the driving pulley on the counter-shaft. Tighten the belt, by means of the ratchet on the bed plate, just sufficiently to keep it from slipping.

Care should be taken not to put more pressure than is necessary on bearings; carelessness in this respect is often followed by heating of the boxes, and possible permanent injury.

The brushes may now be let down upon the commutator, if copper brushes are used.

Move the brushes slowly backward or forward by means of the yoke handle, until there is no sparking at the lower brushes. Clamp the yoke in this position. If the top brushes then spark, move them slightly, one at a time, forward or backward in the brush holder until their non-sparking point is found.

The spring pressure exerted upon the commutator brushes should be just sufficient to produce a good contact without causing cutting. If the brushes cut, the commutator must be smoothed by the use of fine sandpaper, NOT emery cloth.

The generator should run, without load, at the speed given by the manufacturer, and this speed should be closely maintained under all conditions. In the case of generators for incandescent lighting, any increase of speed, above that given, naturally increases the voltage which is prejudicial to the life of the lamps, while a variation below causes unsatisfactory light (see table, page 116).

Before starting a direct current generator, for the first time, if to be run in connection with another or more generators, it should be tested for polarity. This may be done by holding a small pocket compass near the field or pole piece. If the dynamo is connected to be run in multiple with another machine and happens to be polarized wrong, it can be given

the right polarity by lifting the brushes from the commutator, closing the field switch, and then closing the double-pole switch used to throw it in multiple with the other machine, which is supposed to be now running. After the current has been allowed to pass through the fields for a few moments, the double-pole switch can be thrown open, and if a test with the compass is again made the polarity will be found to be the same as the other machine, or machines, and is ready to be started in the usual manner in multiple. (See page 37.)

If the dynamo is to be used in series with another on the three-wire system, and is found to be polarized wrong, it can be given the right polarity by making a temporary connection from the positive brush of the new machine to the positive brush of the machine already in operation; and also a temporary connection from negative brush to negative brush, having first raised the brushes from the commutator and closing the field switch. Keep this connection for a few minutes, then open the field switch and break the temporary connections.

Another test with the compass will show that the polarity of the machine is now correct, and the dynamo is ready to be started in the usual manner in series. (See page 37.)

Assuming that the lamps and lines are all ready, the following precautions should be observed when starting the dynamo:

Be very careful that the brushes are properly set and diametrically opposite each other, as already stated.

Be sure that all connections are securely made, and all nuts or connections firmly set.

In cases where two or more dynamos are connected in multiple by the use of the equalizing connection, care should be taken that the circuit wires from both positive brushes be connected to the same side of the main line, while those from the negative are connected to the other side.

A neat arrangement of the equalizing connection can be made by using triple-pole switches on the switchboard, instead of double-pole switches, and making the equalizing connections through the center pole of the switch, instead of running a cable direct from one dynamo to the other. This method is especially desirable where three or more dynamos are run in multiple.

When dynamos are connected in series, as in the cases where the three-wire system is in use, the leading wire from the positive brush of one machine is connected to the negative brush of the other. The other two brushes (negative and positive) are connected to the two main wires on the outside of the system, while the third or neutral wire is connected to the conductor between the two generators.

Keep all commutator and brush holder insulations free from dust, gritty substances and oil. They should be carefully cleaned once a day.

If any of the connections of the machine become heated, examination will show that the metal surfaces are not clean or not in perfect contact.

The Commutator should be kept clean and allowed to polish or glaze itself while running. No

oil is necessary unless the brushes cut, and then only at the point of cutting. A cloth slightly greased with vaseline is best for the purpose. Never use sandpaper on the commutator without first lifting the brushes. Otherwise, the grit will stick to the brushes and cut the commutator.

Hot Bearings. The most natural thing to do is to shut the machine down, but this should never be done until the following alternatives have been tried and have failed:

First—Lighten the load.

Second—Slacken the belt.

Third—Loosen the caps on the boxes a little.

Fourth—Put more oil in bearings.

Fifth—If all the above fail to remedy the heating, use a heavy lubricant, such as vaseline or cylinder oil. Should the heating then diminish, the shaft must be polished with crocus cloth and the boxes scraped at the first opportunity.

Sixth—Under no conditions put ice upon the bearings unless you are perfectly familiar with such a procedure.

Seventh—If it is absolutely necessary to shut down, get the belt off as soon as possible, keeping the machine revolving meanwhile in order to prevent sticking, and at the same time take off the caps of the bearings. Do not stop the flow of oil to the bearings. When the caps have been taken off, stop the machine and get the linings out immediately, and allow them to cool in the air. Do not throw the linings into cold water, as it would be apt to spring them.

Scraping should be done only by an experienced

person, otherwise the linings may be ruined. Polish the shaft with crocus cloth, or, if badly cut, file with a very fine file, and afterward polish with crocus. Wipe the shaft, as well as the boxes, very carefully, as perhaps grit has been the cause of the hot box. Inspect the bearings, see that they are in line, that the shaft has not been sprung, and that the oil collar does not bear against the box.

Oily Waste should be kept in approved metal cans (made entirely of metal, with legs raising them at least three inches above the floor, and with self-closing covers) and removed daily.

Attendance. A competent man should always be kept on duty where generators are operating.

MOTORS.

The Installation of Motors. All direct-current motors for 550 volts or less, should be insulated on wooden floors or base frames, which should be kept filled to prevent absorption of moisture; and kept clean and dry. Where frame insulation is impracticable the Inspection Department having jurisdiction may, in writing, permit its omission, in which case the frame should be permanently and effectively grounded. The use of motors operating at a potential in excess of 550 volts will only be approved when every practicable safeguard has been provided. They should have no exposed live metal parts and their base frames, in every case, should be permanently and effectively grounded, as in the case of generators. Plans for such installations should be submitted, for approval, to the Inspection Department having jurisdiction before any work is begun.

A high-voltage machine which, on account of great weight or for other reasons, cannot have its frame insulated, should have its frame permanently grounded and should be surrounded with an insulated platform. This may be made of wood, mounted on insulating supports, and so arranged that a man must stand upon it in order to touch any part of the machine. Motors operating at a potential of 550 volts or less should be wired with the same precautions as required for lighting wires carrying a current of the same volume.

Motors operating at a potential between 550 and 3,500 volts should be wired with approved multiple conductor, metal sheathed cable in approved metal conduit firmly secured in place. The metal sheath should be permanently and effectively grounded, and the construction and installation of the conduit should conform to rules for interior conduits, except that at outlets approved outlet bushings should be used in place of the outlet box.

The leads or branch circuits from the source of supply should be designed to carry a current at least 25 per cent. greater than that required by the rated capacity of the motor to provide for the inevitable excess current used by the motor at times, especially when starting, without overfusing the wires. Where the wires would be overfused, in order to provide for the starting current, as in the case of many of the alternating current motors, the wires should be of such size as to be properly protected by these larger fuses.

The insulation of the several conductors for high voltage motors, where leaving the metal sheath at

outlets, should be thoroughly protected from moisture and mechanical injury. This may be accomplished by means of a pot head or some equivalent device. The conduit should be substantially bonded to the metal casings of all fittings and apparatus connected to the inside high tension circuit. It would be much preferable to make the conduit system continuous throughout by connecting the conduit to fittings and motors by means of screw joints, and this construction is strongly recommended wherever practicable.

High voltage motors should preferably be so located that the amount of inside wiring will be reduced to a minimum.

The Inspection Department having jurisdiction may permit the wire for high voltage motors to be installed according to the general rules for high voltage systems when the outside wires directly enter a motor room. Under these conditions there would generally be but a few feet of wire inside the building and none outside the motor room.

The motor and the rheostat should be protected by a cutout or circuit breaker, and controlled by a switch (see illustrations on pages 33 to 37), said switch plainly indicating whether "on" or "off." Small motors may be grouped under the protection of a single set of fuses, provided the rated capacity of the fuses does not exceed 6 amperes. Where one-fourth horse-power or less is used on circuits where the voltage does not exceed 300, a single-pole switch will be accepted. The switch and rheostat should be located within sight of the motor, except in such cases where special permission to

locate them elsewhere is given, in writing, by the Inspection Department having jurisdiction.

In connection with motors the use of circuit-breakers, automatic rheostats with automatic under-load switches is recommended, wherever it is possible to install them.

Where the circuit-breaking device on the motor-starting rheostat disconnects all wires of the circuit, the switch called for in this section may be omitted. Overload-release devices on motor-starting rheostats should not be considered to take the place of the cut-out required by this section if they are inoperative during the starting of the motor.

The switch is necessary for entirely disconnecting the motor when not in use, and the cut-out to protect the motor from excessive currents due to accidents or careless handling when starting. An automatic circuit-breaker disconnecting all wires of the circuit may, however, serve as both switch and cut-out. The use of circuit-breakers with motors is recommended, and may be required by the Inspection Department having jurisdiction.

To be safe, a rheostat should have as great a carrying capacity as the motor itself, or else the arm should have a strong spring-throw attachment, so arranged that it cannot remain at any intermediate position unless purposely held there. See cut on page 27.

Auto starters, unless equipped with tight casings enclosing all current-carrying parts, should be treated about the same as knife switches, and in all wet, dusty or linty places, should be enclosed in dust-tight, fireproof cabinets. If a special motor

room is provided, the starting apparatus and safety devices should be included within it. Where there is any liability of short circuits across their exposed live parts being caused by accidental contacts, they should either be enclosed in cabinets, or else a railing should be erected around them to keep unauthorized persons away from their immediate vicinity.

Motors should not be run in series-multiple or multiple-series, except on constant-potential systems, and then only by special permission of the Inspection Department having jurisdiction.

Like generators, they should be covered with a waterproof cover when not in use, and, if necessary, should be inclosed in an approved case.

When it is necessary to locate a motor in the vicinity of combustibles or in wet or very dusty or dirty places, it is generally advisable to enclose it in a dust-tight fireproof cabinet.

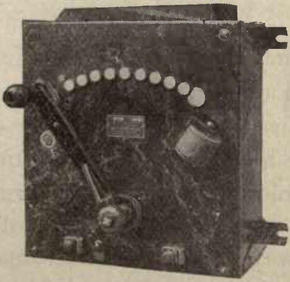
Such enclosures should be readily accessible and sufficiently ventilated to prevent an excessive rise of temperature. The sides should preferably be made largely of glass, so that the motor may be always plainly visible. This lessens the chance of its being neglected, and allows any derangement to be more readily noticed.

The use of the enclosed type of motor is recommended in dusty places, being preferable to wooden boxing.

Motors, when combined with ceiling fans, should be hung from insulated hooks, or else there should be an insulator interposed between the motor and its support.

Every motor should be provided with a name-plate, giving the maker's name, the capacity in volts and amperes, and the normal speed in revolutions per minute.

Starting and Stopping Motors (Direct Current) One rule at all times to be remembered in starting and stopping motors is, *switch first, rheostat last,* which means, in starting, *close the switch first,* and then gradually cut out all resistance as the motor speeds up. To stop the motor *open the switch first* and then cut in all the resistance of the rheostat



Motor Starting Rheostat or "Resistance Box" with No-Voltage Release. Slate front carries lever, contacts and release spool, mounted on a ventilated box of pressed steel which serves as a container for the resistance.

which is in series with the motor armature. When starting any new motor for the first time, see that the belt is removed from the pulley and the motor started with no load. Never keep the rheostat handle on any of its coils longer than a moment, as they are not designed to regulate the speed of the motor, but to prevent too large a flow of current into the armature before the latter has attained its full speed.

The illustration (p. 27) shows a rheostat which is designed to automatically protect the armature of a motor. The contact arm is fitted with a spring which constantly tends to throw the arm on the "off-point" and open the circuit, but is prevented from so doing, while the motor is in operation, by the small electro-magnet, shown on the face of the rheostat, which consists of low resistance coil connected in series with the field winding of the motor. This magnet holds the contact arm of the rheostat in the position, allowing the maximum working current to flow through the armature while it is in operation.

If, for some reason or other, the current supplied to the motor be momentarily cut off, the speed of the armature generates a counter current which also tends to hold the arm in position as long as there is any motion to the motor armature, but as soon as the armature ceases to revolve all current ceases to flow through the electromagnet, thereby releasing the rheostat handle, which flies back to the "off" point, as shown in the illustration, and the motor armature is out of danger. Such a device is of great value where inexperienced men have to handle motors, and are unaware that the first thing to be done when a motor stops for any reason whatever is to open the circuit, and then cut in all the resistance in the rheostat to prevent too large an in-rush of current when the motor is started up again.

The Circuit Breaker for under and over loads is also a most valuable protection in such cases.

Motor Wiring Formulae—(Direct Current). To find the proper size of wire for direct-current motors proceed as follows:

e = voltage of motor.

d = single distance from generator to motor in feet.

v = volts loss in lines.

k = efficiency of motor. (See table below.)

10.8 = Resistance in ohms of a wire 1 ft long and .001 inch diameter. Then in size or wire circular mils (cm)

$$\text{c.m.} = \frac{\text{horsepower} \times 746 \times 2d \times 10.8}{e \times v \times k}$$

$$\text{or simplified cm} = \frac{\text{horsepower} \times d \times 16113.6}{e \times v \times k}$$

Compare the size of wire thus found with that allowed by the underwriters for full load current of motor, + 25%. If it be smaller it must be increased to at least that figure to be approved and the resulting lower line loss accepted. (See table, p. 81.)

THE AVERAGE MOTOR EFFICIENCY (K).

1 h.p. and under	75 per cent.
3 h.p. to 5 h.p.	80 per cent.
5 h.p. to 10 h.p.	85 to 90 per cent.
Over 10 h.p.	90 per cent.

The tables and examples worked out on pages 52-54 and 69-71 will give the desired results, in many cases of smaller installations without having to use the above direct current formulæ.

CURRENT REQUIRED BY MOTOR
(Direct Current.)

To find current required by a motor when the horse-power, efficiency and voltage are known, use the following formula:

Let C = current to be found.

H. P = horse-power of motor.

E = voltage of motor circuit.

K = efficiency of motor in per cent.

$$C = \frac{H. P. \times 746 \times 100}{E \times K}.$$

The table of "amperes per motor" given on the following page, will, in many cases, prevent the trouble of working out the above formula.

By adding the volts indicated in the (page 32) table to the voltage of the lamp or motor, the result shows the voltage at the dynamo for losses indicated. Thus, 10 per cent. on 110 volt system is: 12.22 volts added to 110 equal 122.22, showing that the dynamo must generate 122.22 volts to take care of a 10 per cent. loss in the line (for A. C., see pp. 70-78).

SIZES OF FUSES, IN AMPERES, FOR MOTORS EQUIPPED WITH OVERLOAD STARTING RHEOSTATS.

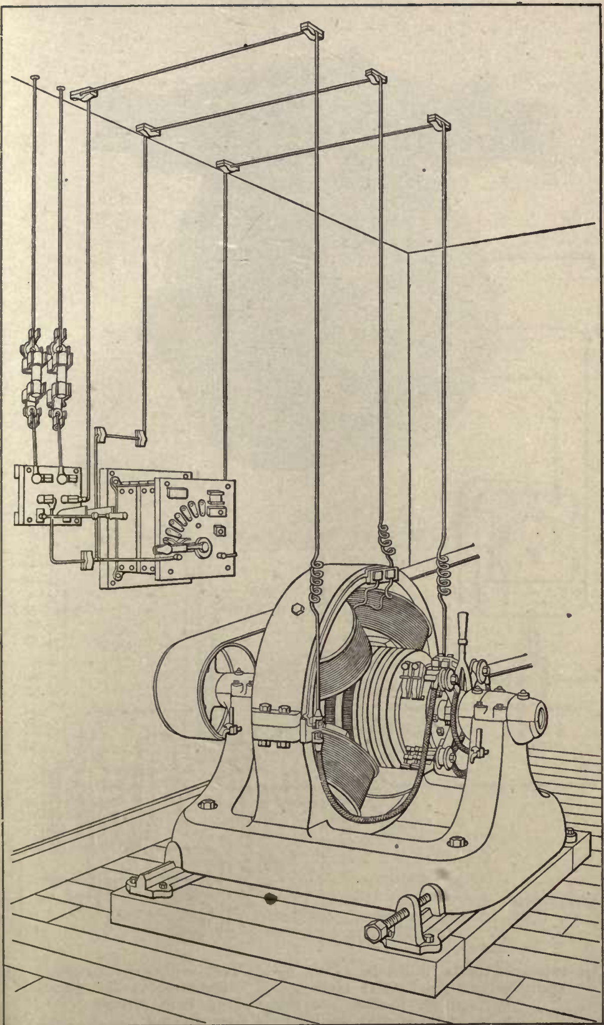
Horsepower.	115 Volts.	230 Volts.	500 Volts.
0.5	8	4	2
1	15	8	4
2	30	15	7
3	40	20	10
4	50	25	12
5	60	30	15
7.5	90	45	20
10	115	60	25
15	175	90	40
20	225	115	50
25	300	150	60
30	350	175	75
35	400	200	90
40	450	225	100
50	600	300	125

AMPERES PER MOTOR.

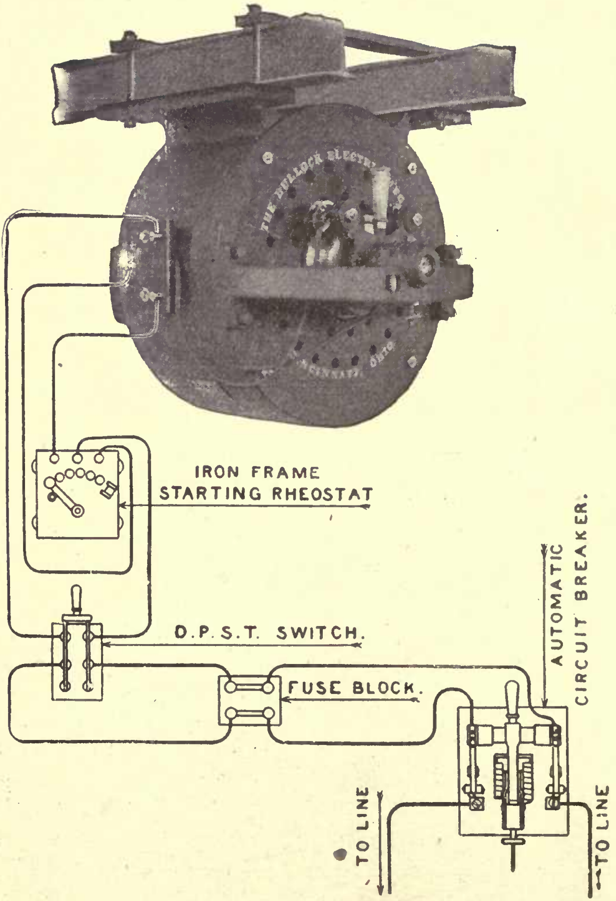
H. P.	Per Cent. Eff.	Watts.	The Top Row Indicates Volts.									
			50	75	110	220	400	500	600	800	1000	1200
3/4	75	746	14.9	9.95	6.78	3.39	1.87	1.49	1.24	.93	.746	.62
1 1/2	75	1492	29.8	19.9	13.56	6.78	3.73	2.98	2.49	1.87	1.492	1.24
3	80	2797	55.9	37.3	25.4	12.7	6.99	5.59	4.66	3.50	2.797	2.33
5	80	4662	93.2	62.2	42.4	21.2	11.74	9.32	7.77	5.83	4.662	3.88
7 1/2	90	6217	124.	82.9	56.5	28.3	15.54	12.43	10.38	7.77	6.217	5.18
10	90	8288	166.	111.	75.3	37.7	20.72	16.57	13.81	10.36	8.288	6.91
15	90	12433	249.	166.	113.	56.5	31.08	24.86	20.72	15.54	12.43	10.36
20	90	16578	332.	221.	151.	75.5	41.45	33.15	27.63	20.72	16.58	13.81
25	90	20722	414.	276.	188.	94.1	51.8	41.4	34.5	25.9	20.7	17.3
30	90	24866	497.	331.	226.	113.	62.2	49.7	41.4	31.	24.9	20.7
40	90	33155	663.	442.	301.	151.	82.9	66.3	55.3	41.4	33.2	27.6
50	90	41444	829.	553.	377.	189.	101.	82.9	69.	51.8	41.4	34.5
60	90	49733	995.	663.	452.	226.	124.	99.5	82.9	62.	49.7	41.4
70	90	58022	1160.	773.	527.	264.	145.	116.	96.7	72.5	58.	48.4
80	90	66310	1326.	884.	603.	303.	166.	133.	111.	82.9	66.3	55.3
90	90	74599	1492.	995.	678.	339.	187.	149.	124.	93.	74.6	62.
100	90	82888	1658.	1105.	754.	377.	207.	166.	138.	104.	82.9	69.
120	90	99467	1989.	1326.	904.	452.	249.	199.	166.	124.	99.	82.9
150	90	124333	2487.	1658.	1130.	565.	311.	249.	207.	155.	124.	104.

VOLTS LOST AT DIFFERENT PER CENT. DROP.

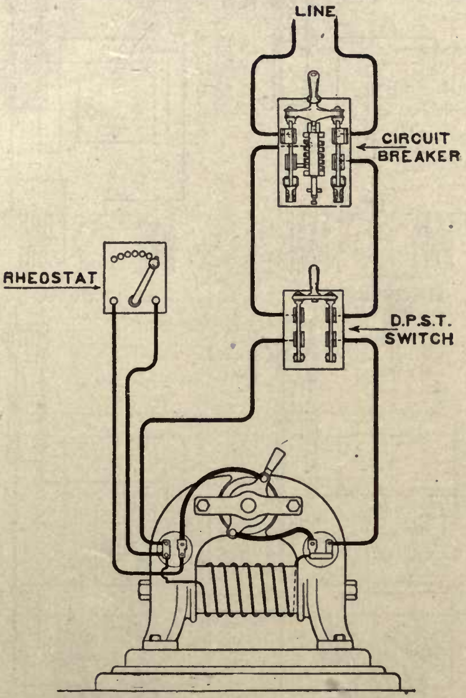
TERMIN'L VOLTS	52	104	110	120	240	550	1100	2200	6600	11000
%										
.5	.261	.523	.553	.603	1.21	2.76	5.53	11.06	33.17	55.28
1.	.525	1.05	1.11	1.21	2.42	5.56	11.11	22.22	66.67	111.11
1.5	.791	1.58	1.68	1.83	3.65	8.38	16.75	33.50	100.50	167.51
2.	1.06	2.12	2.24	2.45	4.90	11.22	22.45	44.90	132.65	224.48
2.5	1.33	2.67	2.82	3.08	6.15	14.10	28.21	56.41	169.23	282.05
3.	1.61	3.22	3.40	3.71	7.42	17.01	34.02	68.04	204.11	340.20
3.5	1.89	3.77	3.99	4.35	8.70	19.95	39.90	79.79	239.37	398.96
4.	2.17	4,33	4.58	5.00	10.00	22.92	45.83	91.67	275.00	458.33
5.	2.74	5.47	5.79	6.32	12.63	28.95	57.90	115.79	347.36	578.94
6.	3.32	6.70	7.02	7.66	15.32	35.11	70.21	140.42	421.27	702.12
7.	3.91	7.83	8.28	9.03	18.06	41.40	82.80	165.59	496.77	827.95
8.	4.52	9.04	9.57	10.43	20.87	47.83	95.65	191.30	573.90	956.52
9.	5.14	10.29	10.88	11.87	23.74	54.40	108.79	217.58	652.75	1087.91
10.	5.78	11.56	12.22	13.33	26.67	61.11	122.22	244.44	733.33	1222.21
11.	6.43	12.85	13.59	14.83	28.66	67.97	135,95	271.90	815.69	1359.49
12.	7.09	14.18	15.00	16.36	32.72	75.00	150.00	299.99	899.98	1499.96
13.	7.77	15.54	16.44	17.93	35.86	82.18	164.36	328.72	986.17	1643.62
14.	8.46	16.93	17.91	19.53	39.07	89.53	179.07	358.14	1074.41	1790.69
15.	9.17	18.35	19.41	21.18	42.35	97.06	194.12	388.23	1164.70	1941.17
20.	13.00	26.00	27.50	30.00	60.00	137.50	275.00	550.00	1650.00	2750.00
25.	17.33	34.67	36.67	40.00	80.00	183.33	366.66	733.33	2199.98	3666.63



An approved installation in every detail, and wiring connections for shunt-wound, four-pole motor, using two enclosed fuses instead of circuit breaker.

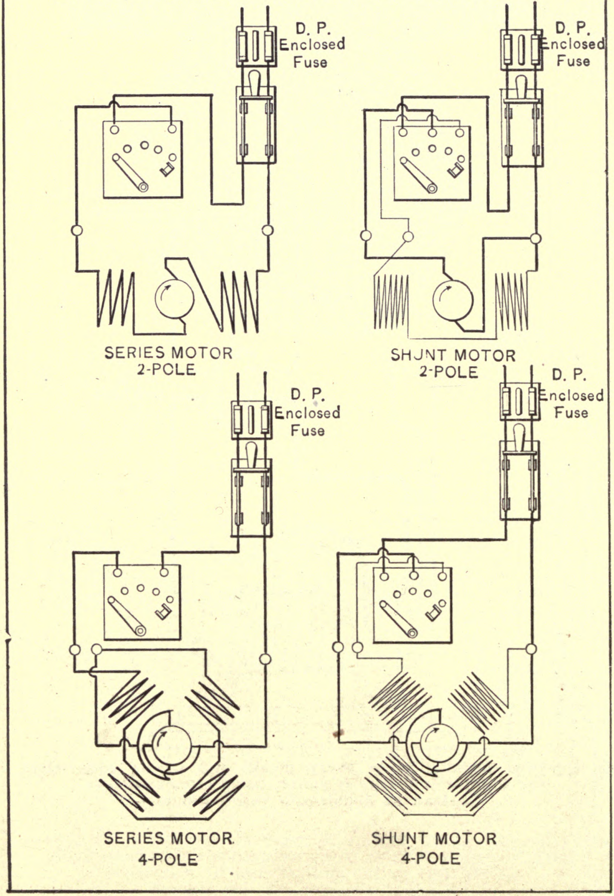


An approved installation in every detail and wiring connections for shunt-wound multipolar slow speed ceiling motor for direct connection to line shafting, using both circuit breaker and double-pole fuse cut-out.

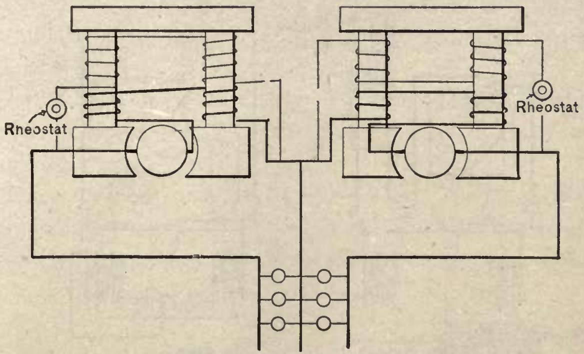


An approved installation in every detail, and wiring connections, for shunt-wound bipolar motor, using circuit breaker instead of double-pole fuse cut-out.

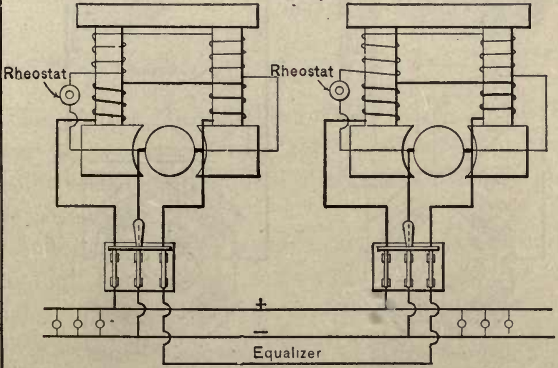
CONNECTIONS FOR DIRECT CURRENT MOTORS



CONNECTIONS FOR DIRECT CURRENT DYNAMOS.

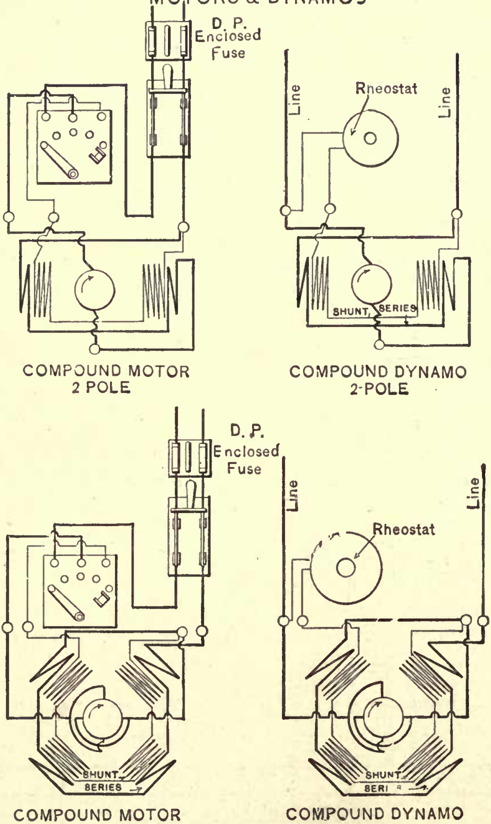


THREE WIRE DISTRIBUTION



MULTIPLE DISTRIBUTION-TWO WIRE

CONNECTIONS FOR DIRECT CURRENT MOTORS & DYNAMOS



COMPOUND MOTOR
2 POLE

COMPOUND DYNAMO
2-POLE

COMPOUND MOTOR
4-POLE

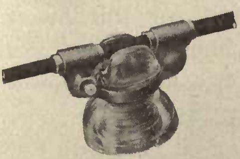
COMPOUND DYNAMO
4-POLE

OUTSIDE WIRING AND CONSTRUCTION

Service Wires (those leading from the outside main wire to the buildings and attached to same) should be "Rubber Covered," as described on page 66, under that heading.

Line Wires, other than service wire, should have an approved "weatherproof" covering. (See page 67.)

Bare Wires may be used through uninhabited and isolated territories free from all other wires, as in such places wire covering would be of little use, as it is not relied on for pole insulation.



For Insulated Wires.

For Bare Wire or Cable.

Insulator Clamps.

Tie Wires should have an insulation equal to that of the conductors they confine, within city limits, or some permanent clamp that will not injure the insulation.

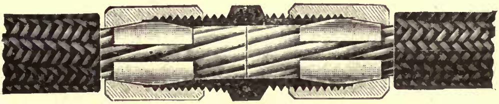
Space between Wires for outside work, whether for high or low tension, should be at least one foot, and care should be exercised to prevent any possibility of a cross connection by water. Wires should never come in contact with anything except their insulators.

Roof Structures. If it should become necessary to run wires over a building, the wires should

be supported on racks which will raise them from 7 to 12 feet above flat roofs, as shown on page 43, or at least one foot above the ridge of pitched roofs, and should be strongly made.

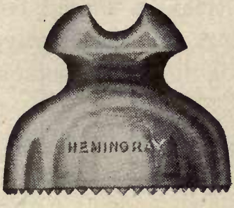
Guard Arms. Whenever sharp corners are turned, each cross arm should be provided with a dead insulated guard arm, or guard iron, to prevent the wires from dropping down and creating trouble, should their insulating support give way. (See Fig. 2, page 64.)

Petticoat Insulators (See illustrations on page 41) should be used exclusively for all outside work, and especially on cross arms, racks, roof structures and service blocks. Porcelain knobs, cleats or rubber hooks should never be used for this heavy outside work. In fact, rubber hooks are not now approved for any form of electric light or power work.



The Dossert Solderless Cable Connector approved for use on stranded wires and cables without the use of solder.

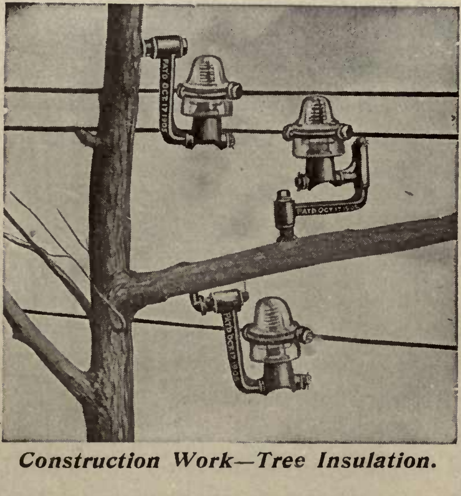
Splicing of two pieces of wire or cable should be so done as to be mechanically and electrically secure without solder. They should then be soldered, unless made with some form of *approved* splicing device. This ruling applies to joints and splices in all classes of wiring. All joints whether soldered or made with an approved splicing device should be covered with an insulation equal to that of the conductors.



3000 Volts 10000 Volts 5000 Volts

6000 Volts 4000 Volts 15000 Volts

Types of Petticoat Insulators for high voltages.



Construction Work—Tree Insulation.

Tree Wiring. Whenever a line passes through the branches of trees, it should be properly supported by insulators, as shown on page 41, to prevent the chafing of the wire insulation and grounding the circuit.

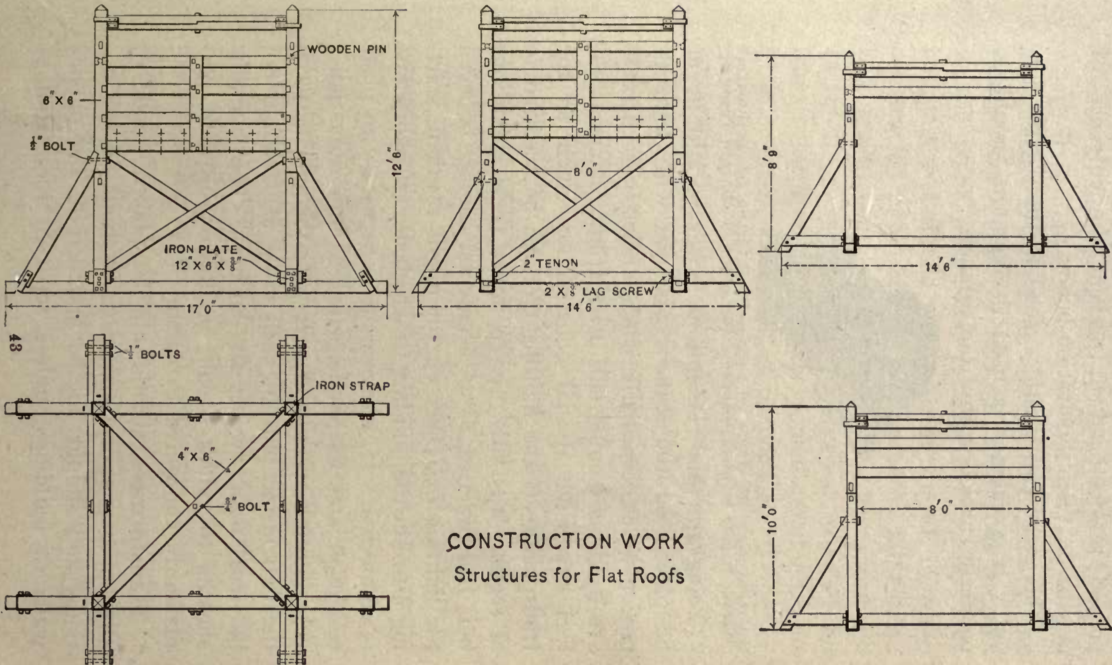
The tree insulators shown on the previous page have proved themselves to be the most practical and permanent insulators for all kinds of tree construction, allowing the free swaying of limbs without chafing the insulation of the wires.

Service Blocks which are attached to buildings should have at least two coats of waterproof paint to prevent the absorption of moisture.

Size of Wire. To find the required size of wire in circular mils for any alternating current system, to carry any required current any distance at any voltage and with any required loss, use the formulæ and examples on pages 69 to 78, and for direct currents the formulæ on pages 198 and 199. When possible, however, refer to tables No. 1 or No. 2 on pages 52 and 69, respectively, as they will be found much simpler when within their limitations.

Service Wires. Where service wires enter a building they should have drip loops outside and the holes through which the conductors pass should be bushed with non-combustible, non-absorptive insulating tubes, such as glass or porcelain, slanting upward toward the inside.

Where metal conduit is used the conduit should be curved downward at its outer end and carefully sealed or, a much better method is to use an ap-



CONSTRUCTION WORK
Structures for Flat Roofs

proved service-head to prevent the entrance of moisture. (See illustration below.)

The inner end should extend to the service cut-out. If a cabinet is used the conduit should be properly carried within the cabinet.

G-V Universal—An Approved Service Head for Service or Entrance Wires. It may be used in either a Horizontal or Vertical Position.

Telegraph and Telephone wires should never be placed on the same cross arm with light or power wires, especially when alternating currents are used, as trouble will arise from induction, unless expensive special construction, such as the transposing of the lighting circuits, be resorted to at regular intervals. Even under these conditions it is bad practice, as an accidental contact between the lighting or power circuit might result in starting a fire in the building to which the telephone line is connected. If, however, it is necessary to place telegraph and telephone wires of the same poles with lighting and power wires, the distance between the two inside pins of each cross arm should not be less than twenty-six inches. The metallic sheaths to cables should be thoroughly and permanently connected to earth.

Transformers should not be placed inside of any building excepting central stations or sub-stations, and should not be attached to the outside walls of buildings, unless separted therefrom by

substantial supports as shown on page 49. In cases where it is impossible to exclude the transformer and primary wiring from entering the building, the transformer should be located as near as possible to the point where the primary wires enter the building, and should be placed in a vault or room constructed of or lined with fire-resisting material, and should contain nothing but the transformers. It is, of course, the safest practice to place all transformers on poles away from the building that is to be wired, as illustrated on page 49.

Where transformers are to be connected to high-voltage circuits, it is necessary in many cases, for best protection to life and property, that the secondary system be permanently grounded, and provision should be made for it when the transformers are installed.

Grounding of Low-Potential Circuits. The grounding of low-potential circuits is only recommended when such circuits are so arranged that under normal conditions of service there will be no appreciable passage of current over the ground wire.

In Direct-Current 3-Wire Systems, the neutral wire should be grounded, and when grounded the following suggestions should be complied with:

1—They should be grounded at the central station on a metal plate buried in coke beneath permanent moisture level, and also through all available underground water and gas pipe systems.

2—In underground systems the neutral wire should also be grounded at each distributing box through the box.

3—In overhead systems the neutral wire should be grounded every 500 feet.

In Alternating-Current Secondary Systems. All transformer secondaries of distributing systems should be grounded, and the following suggestions should be complied with:

1—The grounding should be made at the neutral point or wire, whenever a neutral point or wire is accessible.

2—When no neutral point or wire is accessible one side of the secondary circuit should be grounded.

3—The ground connection should be at the transformer or on the individual service and when transformers feed systems with a neutral wire, the neutral wire should also be grounded at least every 500 feet.

Inspection Departments having jurisdiction may *require* grounding if they deem it necessary.

Ground Connections. When the ground connections is inside of any building, or the ground wire is inside of, or attached to any building (except central or sub-stations) the ground wire should be of copper and have an approved rubber insulating covering.

The ground wire in direct-current 3-wire systems should not at central stations be smaller than the neutral wire and not smaller than No. 6 B. & S. gage elsewhere. The ground wire in alternating-current systems should never be less than No. 6 B. & S. gage.

On 3-phase systems, the ground wire should

have a carrying capacity equal to that of any one of the three mains.

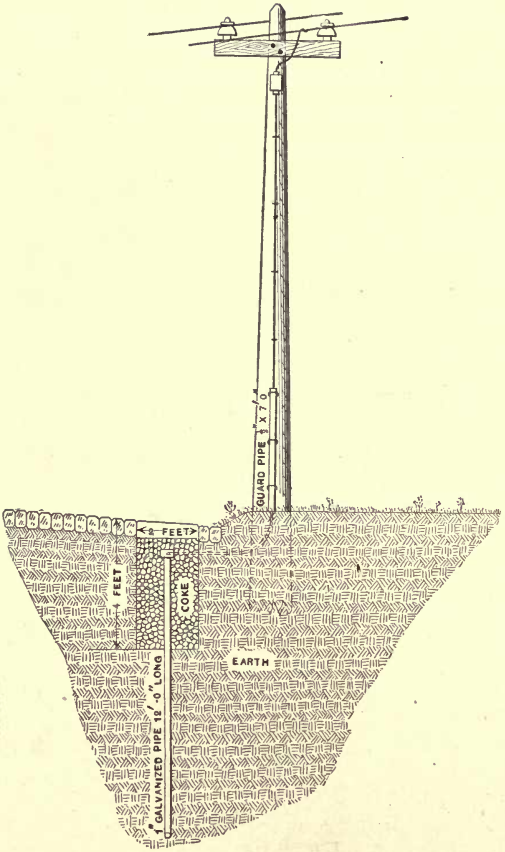
The ground wire should, except for central stations and transformer sub-stations, be kept outside of buildings as far as practicable, but may be directly attached to the building or pole by cleats or porcelain knobs. Staples should never be used. The wire should be carried in as nearly a straight line as practicable, avoiding kinks, coils and sharp bends, and should be protected when exposed to mechanical injury.

This protection can be secured by use of an approved molding, and as a rule the ground wire on the outside of a building should be in moulding at all places where it is in within seven feet from the ground. Conduit may be used for this purpose.

The ground connections for central stations, transformers, sub-stations, and banks of transformers should be made through metal plates buried in coke below permanent moisture level, and connection should also be made to all available underground piping systems, including the lead sheath of underground cables.

For individual transformers and building services, the ground connection may be made to water piping systems running into buildings. This connection may be made by carrying the ground wire into the cellar and connecting on the street side of meters, main cocks, etc.

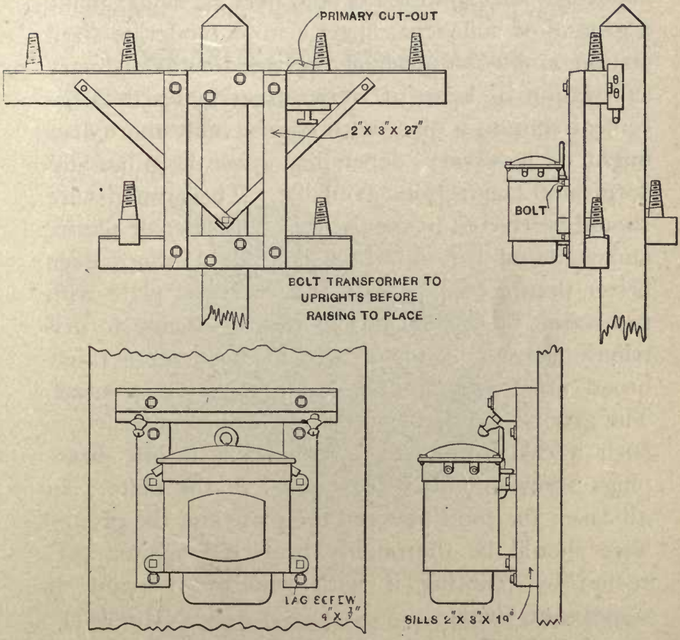
Where it is necessary to run the ground wire through any part of a building it should be protected by approved porcelain bushings through walls or partitions and should be run in approved mould-



Installation of Lightning Arrester on outside lines, showing method of obtaining a good "ground."

ing, or conduit, except that in basements it may be supported on porcelain.

In connecting a ground wire to a piping system, the wire should be sweated into a lug attached to an approved clamp, and the clamp firmly bolted to



Construction Work—Installation of Transformers.

the water pipe after all rust and scale have been removed; or be soldered into a brass plug and the plug forcibly screwed into a pipe-fitting, or, where the pipes are cast iron, into a hole tapped into the pipe itself. For large stations, where connecting to underground pipes with bell and spigot joints,

it is well to connect to several lengths, as the pipe joints may be of rather high resistance.

Where ground plates are used, a No. 16 Stubbs' gage copper plate, about three by six feet in size, with about two feet of crushed coke or charcoal, about pea size, both under and over it, would make a ground of sufficient capacity for a moderate-sized station, and would probably answer for the ordinary sub-station or bank of transformers. For a large central station, a plate with considerably more area might be necessary, depending upon the other underground connections available. The ground wire should be riveted to the plate in a number of places, and soldered for its whole length. Perhaps even better than a copper plate is a cast-iron plate with projecting forks, the idea of the fork being to distribute the connection to the ground over a fairly broad area, and to give a large surface contact. The ground wire can probably best be connected to such a cast-iron plate by soldering it into brass plugs screwed into holes tapped in the plate. In all cases, the joint between the plate and the ground wire should be thoroughly protected against corrosion by painting it with waterproof paint or some equivalent.

Ground Detectors. The cuts on page 65 illustrate a few practical methods of detecting grounds on alternating and direct current circuits which have not been purposely grounded, as described on pages 45 and 46.

In using any one of these methods for detecting grounds always see that the circuit TO GROUND is

left open after testing the outside circuits. Some central station men are in the habit of leaving the ground circuit closed on one side constantly in order that any ground that might occur on the other side may be instantly noticed. This, however, is bad practice, as it greatly reduces the insulation of the whole system. Test all circuits once a day.

MEASURING RESISTANCE

It is frequently necessary to know just what the insulation resistance of a line, or the wiring in a building, is in ohms.

The "Megger" for Measuring Resistance.

Heretofore such tests have been made with some form of portable testing set (Wheatstone Bridge), or by the voltmeter method; inconvenient calculations being necessary in either case.

Now, however, there is on the market a new instrument, called the Evershed Megger, by means of which conductor or insulation resistance can be measured as quickly and as accurately as volt-

age is measured with a voltmeter. A small hand generator is mounted in the case, so that no outside source of current is required.

Tests by the "Megger-method" are made as follows: Connect a wire from one side of the circuit to binding post of the Megger marked "Line," and with another piece of wire connect a water pipe to the "earth" binding post of the Megger. Turn the generator handle at one end of the Megger case, and the pointer of the instrument will instantly show the correct resistance—the scale being graduated in ohms.

As the generator voltage is usually 100 or 250 volts, there is the added advantage that tests by the "Megger-method" are practically made under working conditions.

Wiring Table No. 1. For Direct Current Work.

Size of Wire, B. & S. Gauge.	Feet per Volt-Ampere.
0000	10068.4
000	7998.7
00	6339.5
0	5025.1
1	3974.5
2	3166.5
3	2495.0
4	1980.0
5	1347.0
6	1248.7
7	986.7
8	779.6
9	618.4
10	495.0
11	394.0
12	312.3
13	246.7
14	194.

How to Use the Wiring Table No. 1. The column entitled size of wire B. & S. gage gives the various sizes used in wiring. The column entitled feet per volt-ampere gives the number or feet that the adjacent size of wire will transmit one ampere with a lost of one volt; this is a constant quantity for each size of wire.

The distance that a wire will transmit a given current is directly proportional to the volts lost.

The distance that a wire will transmit a current with a certain volt loss is inversely proportional to the current.

If, therefore, it is desired to know how far a given wire will transmit a given current at a certain given line loss, select from the second column opposite the size of the wire constant in the feet? per-volt-ampere column and multiply this figure by the desired loss and divide by the current to be transmitted.

If it is desired to know how much current can be transmitted a given distance with a certain line loss multiply this constant by the line loss and divide by the distance.

If it is desired to know what line loss will occur when transmitting a certain current through a certain size of wire multiply the distance and current together and divide by the constant for the size of wire which it is desired to use.

Take a Practical Example. Let it be asked, "How far will a No. 6 wire transmit 20 amperes with a line loss of 15 volts?" The constant for No. 6 wire is 1248.7; multiply this by the line loss

of 15 volts and we have 18730.5, and dividing this by the current, 20 amperes, we have 936.5. Conversely, suppose we have a distance of 936.5 feet and must transmit over it 20 amperes, how much line loss will obtain? Multiply this distance of 936.5 by the current to be transmitted, and we obtain 18730, dividing this by the constant for No. 6 wire, 1248.7, we obtain 14.999 volts line loss, or practically 15 volts.

Similarly: Suppose we have a distance of 936.5 feet, and the conditions are such that at most it must not exceed a line loss of more than 15 volts. How many amperes can we transmit with a No. 6 wire?

To do this we multiply the constant of No. 6 wire, 1248.7 by the line loss of 15 volts, obtaining 18730.5, and dividing this by the distance, 963.5 feet, we obtain 20.0005, or practically 20 amperes.

Finally, and as is more often the case, the distance and line loss and current are given; we have to multiply the distance by the current and divide by the line loss which will give us the constant of the wire to use. In the preceding case of 936.5 feet, we multiply by the current of 20 amperes and obtain 18730.; dividing this by the line loss of 15 volts we obtain 12486.6, which is practically 12,-487, the constant for No. 6 wire.

If this constant had been larger still, but not so large as the constant for No. 5 wire, it would be proper to select the nearest constant.

Wires for Outside Use have in most cases a "weather-proof" (see page 67) insulation, except service wires, which should be "rubber covered"

see page 66). Any insulating covering for wires exposed to the weather on poles is in time rendered useless. The real insulation of the system is dependent upon the porcelain or glass insulators on which the wires are supported.

Constant-Potential Currents of over 5,000 volts should be given special care and attention as to their installation and location with respect to adjoining or near-by property or other outside wiring.

Accidental crosses between such lines and low-potential lines may allow the high-voltage current to enter buildings over a large section of adjoining country. Moreover, such high-voltage lines, if carried close to buildings, hamper the work of firemen in case of fire in the building.

It is fully understood that it is impossible to frame rules which will cover all conceivable cases that may arise in construction work of such an extended and varied nature.

Every reasonable precaution, however, should be taken in arranging routes so as to avoid exposure to contacts with other electric circuits. On existing lines, where there is a liability to contact, the route should be changed by mutual agreement between the parties in interest wherever possible.

Such lines should not approach other pole lines nearer than a distance equal to the height of the taller pole line, and such lines should not be on the same poles with other wires, except that signaling wires used by the company operating the high-pressure system, and which do not enter property other than that owned or occupied by such company may be carried over the same poles.

Where such lines must necessarily be carried near other pole lines, or where they should necessarily be carried on the same poles with other wires, extra precautions to reduce the liability of a breakdown to a minimum should be taken, such as the use of wires of ample mechanical strength, widely spaced cross arms, short spans, double or extra heavy cross arms, extra heavy pins, insulators, and poles thoroughly supported. If carried on the same pole with other wires, the high-pressure wires should be carried at least three feet above the other wires.

Where such lines cross other lines, the poles of both lines should be of heavy and substantial construction.

Whenever it is feasible, end insulator guards should be placed on the cross arms of the upper line. If the high-pressure wires cross below the other lines, the wires of the upper line should be dead-ended at each end of the span to double-grooved, or to standard transposition insulators, and the line completed by loops.

When it is necessary to carry such high-voltage lines near buildings, they should be at such height and distance from the building as not to interfere with firemen in event of fire; therefore, if within 25 feet of a building, they should be carried at a height not less than that of the front cornice, and the height should be greater than that of the cornice, as the wires come nearer to the building.

It is evident that where the roof of the building continues nearly in line with the walls, as in Mansard roofs, the height and distance of the line

should be reckoned from some part of the roof instead of from the cornice.

POLES FOR LIGHT AND POWER WIRES

It is very essential to a proper installation that the poles receive due consideration, a fact that is too often overlooked.

In selecting the style of pole necessary for a certain class of work, the conditions and circumstances should be considered. They may be arranged in three classes, the size of wire they are to carry being one of the important regulating circumstances.

First Class. Alternating-current plants for lighting small towns. Main line of poles should consist of poles of from 30 to 35 feet with 6-inch tops. These are strong enough for all the weight that is placed upon them. No pole less than 30 feet with 6-inch top should be placed on a corner for lamps. The height of trees, of course, will have to be considered in many cases. For the Edison municipal system, where more than one set of wires are used for street lighting, a 6-inch top should be the size of the poles, the length being not less than 30 feet, and more if the streets be hilly and filled with trees.

Second Class. Town lighting by arc lights. All poles should be at least 6-inch tops. The corner poles should be 6½-inch tops, and wherever the cross arms are placed on a pole at different angles, the pole should be at least a 6½-inch top. A 30-foot pole is sufficiently large for the main

line, but it would be advisable to place 35-foot poles on corners.

Third Class. Where heavy wire, such as No. 00, is used for feeder wire, the poles should be at least 7-inch tops. Where mains are run on the same pole line the strain is somewhat lessened, and poles of smaller size will answer all purposes.

Cull Poles. The question as to what is a cull pole is something on which many authorities differ. Of course, if specifications call for a certain-sized pole, parties supplying the poles should be compelled to send the sizes called for. All poles that are smaller at the top than the sizes agreed upon, are troubled with dry rot, large knots and bumps, have more than one bend, or have a sweep of over twelve inches, should certainly be classed as cull poles. Specifications for electric light and power work should be, and in many cases are, much more severe than those required by telegraph lines. A cull pole, one of good material, is the best thing for a guy stub, and is frequently used for this purpose. A cedar pole is always preferable to any other, owing to the fact that it is very light in comparison to other timber, and is strong, durable, and very long lived.

Pole Setting. In erecting poles, it seems to be the universal opinion of the best posted construction men that a pole should be set at least five feet in the ground, and six inches additional for every five feet additional length above thirty-five feet. Also additional depths on corners. Wherever there is much moisture in the ground, it is of much value to pain or smear the butt ends of the pole

with pitch or tar, allowing this to extend about two feet above the level of the ground. This protects the pole from rot at the base. The weakest part of the pole is just where it enters the ground. Never set poles further than 125 feet apart; spacing not over 110 feet is good practice.

Pole Holes should be dug large enough so that the butt of the pole can be dropped straight in without any forcing, and when the pole is in position only one shovel should be used, to fill in, the earth being thoroughly tamped down with iron tampers at every step until the hole is completely filled with solidly packed earth. Where the ground is too soft for proper tamping, a grouting composed of one part of Portland cement to two parts of sand mixed with broken stone may be used to make an artificial foundation.

Painting. When poles are to be painted, a dark olive green color should be chosen, in order that they may be as inconspicuous as possible. One coat of paint should be applied before pole is set, and one after pole is set. Tops should be pointed to shed water.

All poles 35 feet long and over are usually loaded on two cars.

For chestnut poles add 50 per cent. to weights as given above.

Cross Arms. The distance from the top of the pole to the cross arm should be equal to the diameter of pole at the top. All cross arms should be well painted with one coat of paint before placing, and must be of standard size.

Cross arms of four or more pins should be

braced, using one or two braces as occasion demands. Cross arms on one pole should face those on the next, thereby making the cross arms on every other pole face in one direction. All wooden pins should have their shanks dipped in paint and should be driven into the cross arm while the paint is wet. The upper part of the pin should also be painted. Iron pins can be furnished for corners where there is a heavy strain, but are not advised, it being preferable to use the construction as shown in the diagrams. Put double arms on the pole where feeder wires end. (See p. 64.)

Guard Irons. Guard irons should be placed at all angles in lines and on break arms. (See p. 64.)

Steps. All junction and lamp poles should be stepped so that the distance between steps on the same side of the pole will not be over 36 inches. Poles carrying converters should also be stepped.

Guys. All poles at angles in the line should be properly guyed, using No. 4 B. & S. galvanized iron wire, or two No. 8 wires twisted. All junction poles should also be guyed. Never attach a guy wire to a pole so that it prevents a cross arm from being removed.

For alternating current work, double or triple petticoat insulators are recommended. (See cuts on page 41.)

Primary Wires on Poles. When running more than one alternating current, single-phase primary circuit upon the same line of poles the wires of each circuit should be run parallel and on adjacent pins, as shown below, so as to avoid any fluctuation in the lamps due to induction. The lines lettered A

and A are for circuit No. 1, and B and B for circuit No. 2, etc.

A

A

B

B

Underground Conductors should be protected against moisture and mechanical injury where brought into a building, and all combustible material should be kept from the immediate vicinity.

They should not be so arranged as to shunt the current through a building around any catch-box.

Where underground service enters building through tubes, the tubes shall be tightly closed at outlets with asphaltum or other non-conductor, to prevent gases from entering the building through such channels.

CEDAR POLES FOR ELECTRIC LIGHT WORK.

SIZE.	Average weight, pounds each.	No. of Poles to a Car	SIZE.	Average weight, pounds each.	No. of Poles to a Car
25-ft., 5-inch top	200	150	35-ft., 7-inch top	650	90
25 " 5½ " "	225	130	40 " 6 " "	800	80
25 " 6 " "	250	100	40 " 7 " "	900	75
28 " 7 " "	400	80	45 " 6 " "	900	70
30 " 5 " "	300	110	45 " 7 " "	1000	65
30 " 6 " "	350	90	50 " 6 " "	1200	55
30 " 7 " "	420	75	55 " 6 " "	1400	45
35 " 6 " "	550	100			

POLE LINE DATA

Gauge No. B. & S.	4–0	3–0	2–0	1–0	1	2
Diam. Bare wire, in Thousandths	.460	.40964	.3648	.3249	.2893	.2576
Ohms Res. B. wire at 75° per mile	.2622	.33	.4164	.5252	.6642	.8337
Wt. (lbs.) per 1,000 ft. Triple B.	775	630	490	400	306	268
Wt. " " Mile " "	4092	3326	2587	2112	1616	1415

Poles per Mile	Dist. bet. Poles—Ft.	Approximate Wt. of Weatherproof Wire between Poles					
20	264.00	210.73	171.31	133.24	108.78	83.21	72.87
21	251.40	200.66	163.14	126.87	103.58	77.24	69.39
22	240.10	191.64	155.81	121.17	98.91	75.67	66.27
23	229.56	183.24	148.96	115.85	94.57	72.36	63.36
24	220.00	175.60	142.76	111.03	90.64	69.34	60.72
25	211.20	168.59	137.04	106.58	87.01	66.56	58.29
26	203.07	162.07	131.76	102.48	83.65	64.00	56.05
27	195.55	156.10	126.90	98.69	80.56	61.64	53.97
28	188.55	150.46	122.35	95.16	77.68	59.43	52.05
29	182.09	145.34	118.16	91.89	75.01	57.39	50.26
30	176.00	140.50	114.21	88.83	72.51	55.47	48.58
31	170.30	135.92	110.51	85.95	70.16	53.67	47.00
32	165.00	131.71	107.07	83.28	67.98	52.01	45.55
33	160.00	127.72	103.82	80.75	65.92	50.43	44.16
34	155.29	123.96	100.76	78.37	63.98	48.94	42.86
35	150.85	120.38	97.89	76.14	62.15	47.55	41.64
36	146.66	117.07	95.15	74.02	60.43	46.23	40.48
37	142.70	113.90	92.60	72.02	58.79	44.98	39.39
38	138.96	110.93	90.17	70.13	57.25	43.88	38.36
39	135.38	108.05	87.84	68.33	55.77	42.67	37.37
40	132.00	105.37	85.65	66.62	54.38	41.61	36.43
41	128.78	102.79	83.56	64.99	53.05	40.59	35.54
42	125.71	100.35	81.58	63.44	51.79	39.62	34.70
43	122.79	98.01	79.68	61.97	50.59	38.70	33.89
44	120.00	95.79	77.87	60.56	49.47	37.82	33.12
45	117.33	93.66	76.15	59.21	48.38	36.98	32.38
46	114.78	91.61	74.48	57.93	47.27	36.18	31.68
47	112.34	89.67	72.89	56.70	46.28	35.40	31.01
48	110.00	87.80	71.38	55.52	45.32	34.67	30.36
49	107.75	86.01	69.92	54.38	44.39	33.96	29.74
50	105.60	84.30	68.53	53.29	43.50	33.28	29.15
51	103.52	82.63	67.18	52.24	42.65	32.63	28.57
52	101.53	81.04	65.89	51.24	41.83	32.00	28.02
53	99.64	79.54	64.65	50.29	41.05	31.40	27.50
54	97.77	78.04	63.44	49.34	40.28	30.82	26.98
55	96.00	76.63	65.29	48.45	39.55	30.25	26.50

Gauge No. B. & S.		No. 3	No. 4	No. 5	No. 6.	No. 7	No. 8
Diam. Bare Wire, Thousandths....		.2294	.2043	.1819	.1620	.1442	.1285
Res. B. Wire, per mile at 75°.....		1.058	1.333	1.6748	2.114	2.673	3.387
Wt. 1,000 ft. Triple Braid.........		210	164	145	112		78
Wt. Mile " "		1109	866	766	591		412
Poles Per Mile	Distance Between Poles —Feet	Approximate Wt. of Weatherproof Wire between Poles					
20	264.00	57.10	44.59	39.43	30.45	......	21.21
21	251.40	54.38	42.46	37.54	29.00	......	20.20
22	240.10	51.93	40.55	35.86	27.70	......	18.29
23	229.56	49.65	38.77	34.28	26.48	......	18.44
24	220.00	47.59	37.16	32.86	25.38	......	17.67
25	211.20	45.68	35.68	31.54	24.36	......	16.97
26	203.07	43.92	34.30	30.33	23.42	......	16.32
27	195.55	42.29	33.03	29.21	22.56	......	15.71
28	188.55	40.78	31.85	28.16	21.75	.....	15.15
29	182.09	39.39	30.76	27.19	21.00	......	14.63
30	176.00	38.07	29.73	26.29	20.30	......	14.14
31	170.30	36.83	28.77	25.43	19.64	.....	13.68
32	165.00	35.69	27.87	24.64	19.03	......	13.26
33	160.00	34.61	27.03	23.90	18.46	......	12.85
34	155.29	33.59	26.23	23.19	17.91	......	12.47
35	150.85	32.63	25.48	22.53	17.40	......	12.12
36	146.66	31.72	24.78	21.90	16.92	......	11.78
37	142.70	30.87	24.10	21.31	16.46	......	11.46
38	138.96	30.06	23.47	20.76	16.03	......	11.16
39	135.38	29.28	22.86	20.22	15.62	......	10.88
40	132.00	28.55	22.30	19.71	15.23	......	10.61
41	128.78	27.85	21.75	19.23	14.85	......	10.34
42	125.71	27.19	21.24	18.78	14.50	......	10.10
43	122.79	26.56	20.74	18.34	14.17	......	9.86
44	120.00	25.96	20.27	17.92	13.84	......	9.64
45	117.33	25.38	19.82	17.52	13.53	......	9.43
46	114.78	24.83	19.39	17.14	13.24	......	9.22
47	112.34	24.30	18.98	16.78	12.96	......	9.02
48	110.00	23.79	18.58	16.43	12.69	......	8.84
49	107.75	23.31	18.20	16.09	12.43	......	8.66
50	105.60	22.84	17.84	15.77	12.18	......	8.48
51	103.52	22.39	17.49	15.46	11.95	......	8.32
52	101.53	21.96	17.15	15.16	11.71	......	8.16
53	99.64	21.55	16.83	14.88	11.49	......	8.00
54	97.77	21.15	16.51	14.60	11.28	......	7.85
55	96.00	20.76	16.21	14 34	11.07	......	7.71

Fig. 1.

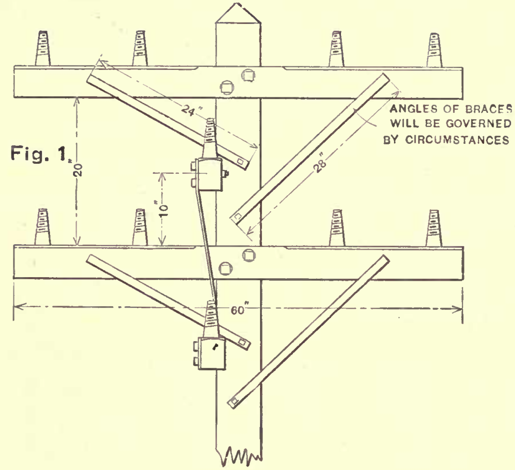
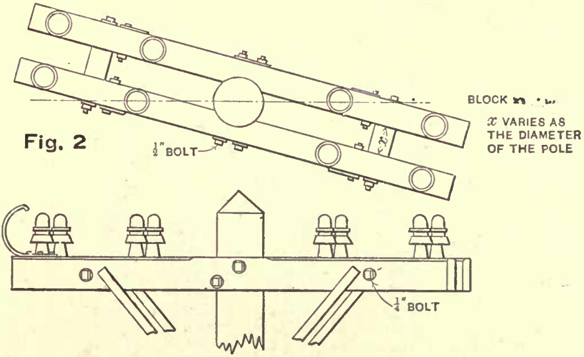


Fig. 2



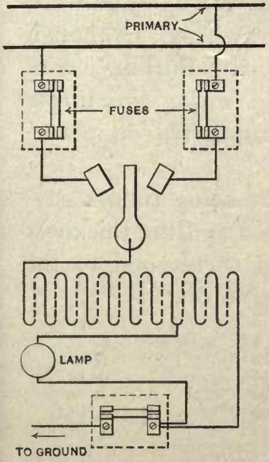
CONSTRUCTION WORK

Position of Cross-Arms when Turning Corners

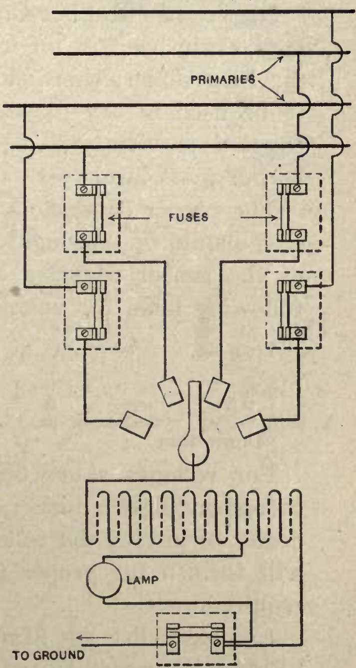
When running a heavy line where it is necessary to use two cross arms fastened as shown in Fig. 2. If lines are not heavy, only one cross arm will be necessary. In case lines cross the street diagonally, the arms where the wires leave and those to which they run are both set at an angle. When turning an abrupt corner, only one arm is turned. The above cannot be used where feeders tap into double branches. In such cases the method as given in Fig. 1 is used.

CONNECTIONS
OF
GROUND DETECTORS

ALTERNATING
GROUND DETECTOR
FOR ONE CIRCUIT

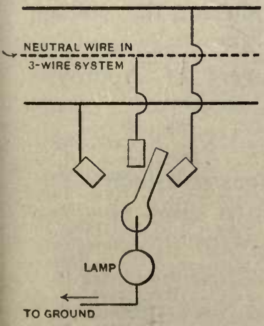


ALTERNATING
GROUND DETECTOR
FOR TWO CIRCUITS



IF THE LAMP BURNS A GROUND IS INDICATED ON THE OPPOSITE SIDE OF THE CIRCUIT FROM THAT TO WHICH THE SWITCH IS CONNECTED

DIRECT CURRENT
GROUND DETECTOR



INSIDE WIRING

General rules for all systems and voltages for light, power and heat, when protected by service cut-out and switch.

Approved "Rubber-Covered Wire" should be used exclusively in all interior wiring. Although the Fire Underwriters allow "Slow Burning" wire to be used in dry places when wiring is entirely exposed to view and rigidly supported on porcelain or glass insulators.

The copper conductors before being rubber covered should be thoroughly tinned and the thickness of the rubber covering should correspond to the following table for voltages up to 600:

From No.	14	to No.	8	inclusive	$\frac{3}{64}$ in.
"	6	to "	2	"	$\frac{1}{16}$ in.
"	1	to "	0000	"	$\frac{5}{64}$ in.
Over	0000	to "	500000 c. m.	"	$\frac{3}{32}$ in.
"	500000 c. m.	to "	1000000 "	"	$\frac{7}{64}$ in.
Larger than		"	1000000 "	"	$\frac{1}{8}$ in.

For voltages above 600 the rubber covering is correspondingly thicker. Consult your supply dealer or any of the following manufacturers who will furnish the proper insulation for the voltage required.

Complete list of Manufacturers of Approved "Rubber Covered" Wires:

A. A. Wire Co., Inc.............................Newark, N. J.
American Electrical Works....................Providence, R. I.
American Steel & Wire Co.....................Worcester, Mass.
Atlantic Insulated Wire & Cable Co.................New York.
Bay State Insulated Wire & Cable Co...........Hyde Park, Mass.
Belden Mfg. Co.................................Chicago, Ill.
Bishop Gutta Percha Co.............................New York.
Boston Insulated Wire & Cable Co......................Boston.
Bourn Rubber Co...............................Providence, R. I.
Collyer Insulated Wire Co.....................Pawtucket, R. I.
Crescent Insulated Wire & Cable Co..............Trenton, N. J.
Detroit Insulated Wire Co........................Detroit, Mich.

Electric Cable Co	Bridgeport, Conn.
General Electric Co	Schenectady, N. Y.
Goodrich Co., B. F	Akron, Ohio.
Goodyear Rubber Insulating Co	New York.
Habirshaw Wire Co	Yonkers, N. Y.
Hazard Mfg. Co	Wilkes-Barre, Pa.
Indiana Rubber & Insulated Wire Co.	Jonesboro, Ind.
Kerite Insulated Wire & Cable Co	New York.
Lowell Insulated Wire Co	Lowell, Mass.
Marion Insulated Wire Co	Marion, Ind.
National India Rubber Co	New York.
New York Insulated Wire Co	New York.
The Okonite Co	New York.
Phillips Insulated Wire Co	Pawtucket, R. I.
Roebling's Sons Co., John A	Trenton, N. J.
Rome Wire Co	Rome, N. Y.
Safety Insulated Wire & Cable Co	New York.
Simplex Wire & Cable Co	Boston.
Standard Underground Cable Co	Pittsburg.
Waterbury Company	New York.

Chicago Insulated Wire & Mfg. Co....................Chicago.
(*Slow-Burning and Weatherproof.*)

"Slow-Burning" Wire should have an insulation consisting of three braids of cotton or other thread with the interstices well filled with a fireproofing compound. The outer braid should be designed to resist abrasion and have its surface finished smooth and hard.

The complete covering should be of a thickness not less than that given in the following table:

Form No.	14 to No.	8	inclusive,	3/64 inch
" "	7 to "	2	"	1/16 "
" "	1 to "	0000	"	5/64 "
	250000 to "	500000 c. m.	"	3/32 "
	500000 to "	1000000 c. m.	"	7/64 "
Larger than	"	1000000 c. m.	"	1/8 "

"Weatherproof" Wire is for out-door use, and should have a covering of at least three braids thoroughly impregnated with a dense moisture repellent which should stand a temperature of 160° Fahrenheit without dripping. The thickness should correspond to that of "Slow Burning" wire, and

the outer surface should be thoroughly slicked down.

Carrying Capacity of Wires. The table on page 81 gives the safe carrying capacity of wires from No. 18 B. & S. to cables of 2,000,000 circular mils. No wires smaller than No. 14 should be used except for fixture wiring and pendant cords. For fixtures as small as No. 18 may be used. (See page 99.)

Tie Wires should have an insulation equal to that of the conductors they confine.

All wires of the size of No. 8 B. & S. gage or larger when used in connection with knobs should be securely tied thereto with tie wires having equal insulation.

Solid porcelain knobs should be used at the end of runs where circuits are terminated. Split knobs or cleats should be used for conductors smaller than No. 8 B. & S. gage, except at the end of runs.

All knobs or cleats should be fastened by screws of generous length and should have washers under their heads to prevent the screw from cracking the porcelain.

Splicing should be done so as to make the wires mechanically and electrically secure without solder; then they should be soldered to insure preservation from corrosion and consequent heating from poor contact. Then thoroughly taped.

All joints should be soldered unless made with some form of *approved* splicing device such as Dossert joints. (See page 40.) This ruling applies to joints and splices in all classes of wiring.

Stranded Wires, except flexible cords, should have their tips soldered before being fastened under clamps or binding screws. Both solid and stranded wires having a conductivity greater than No. 8 B. & S. gage should be soldered into lugs for all terminal connection unless Dossert lugs are used.

Wiring Table, No. 2 (See page 70.) The following examples show the method of using the table on the following page.

1. What size of wire should we use to run 50 50-watt carbon lamps, of 110 volts, a distance of 150 feet to the center of distribution with the loss of 2 volts? First multiply the amperes, which will be 22.75 (50-50 watt 110-v. lamps take 22.75 amperes, see table on page 115), by the distance, 150 feet, which will equal 3,412 ampere feet. Then refer to the columns headed "Actual Volts Lost," and as we are to have only a loss of two volts look down the column headed 2 until you come to the nearest corresponding number to 3,412 and we find that 3,900 is the best number to use. Put your pencil on the number 3,900 and follow that horizontal column to the left until you come to the vertical column headed "Size B. & S." and you find that a No. 4 B. & S. wire will be the proper size to use in this case.

2. What size wire should we use to carry current for a motor that requires 30 amperes and 220 volts, and is situated 200 feet from the distributing pole, the "drop" in volts not to exceed 2 per cent.? First multiply 30 amperes by 200 feet, as we did in the first example, and we get .6,000 ampere feet. Now look at the upper left hand corner of the table

WIRING TABLE FOR LIGHT AND POWER,

Two Wire D. C. and Single Phase, A. C., and Four Wire Two Phase A. C.

Multiply current in amperes for D. C. and single phase, or amperes per phase (when Two Phase Four Wire) by single distance in feet and refer to the nearest corresponding number under column of Actual Volts lost, to find wire size.

Volts.		Percentage of Loss.													
2000		1.2	1.1	1.0	0.75	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05
1000		2.4	2.2	2.0	1.5	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1
500		4.8	4.3	3.9	2.9	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.2
220		10.3	9.3	8.3	6.5	4.4	3.9	3.5	3.1	2.7	2.2	1.8	1.4	0.9	0.45
110		18.5	17.0	15.4	12.0	8.4	7.6	6.8	6.0	5.2	4.4	3.5	2.7	1.8	0.9
52									11.8	10.3	8.8	7.1	5.5	3.7	1.9
		Actual Volts Lost.													
Carrying Capacity *Amperes	Size. B. & S.	25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
225	0000	247000	222300	197600	148200	98800	88920	79040	69160	59280	49400	39520	29640	19760	9880
175	000	196000	176400	156800	117600	78400	70560	62720	54880	47040	39200	31360	23520	15680	7840
150	00	155375	139837	124300	93225	62150	55935	49720	43505	37290	31075	24860	18645	12430	6215
125	0	123250	110925	98600	73950	49300	44370	39440	34510	29580	24650	19720	14790	9860	4930
100	1	97750	87975	78200	58650	39100	35190	31280	27370	23460	19550	15640	11730	7820	3910
90	2	77500	69750	62000	46500	31000	27900	24800	21700	18600	15500	12400	9300	6200	3100
80	3	61500	55350	49200	36900	24600	22140	19680	17220	14760	12300	9840	7380	4920	2460
70	4	48750	43875	39000	29250	19500	17550	15600	13650	11700	9750	7800	5850	3900	1950
55	5	38750	34875	31000	23250	15500	13950	12400	10850	9300	7750	6200	4650	3100	1550
50	6	30750	27675	24600	18450	12300	11070	9840	8610	7380	6150	4920	3690	2460	1230
35	8	19275	17347	15420	11565	7710	6939	6168	5397	4626	3855	3084	2313	1542	771
25	10	12125	10912	9700	7275	4850	4365	3880	3395	2910	2425	1940	1455	970	485
20	12	7625	6862	6100	4575	3050	2745	2440	2135	1830	1525	1220	915	610	305
15	14	4800	4320	3840	2880	1920	1728	1536	1344	1152	960	768	576	384	192

Note:—In case a larger loss than any given in the table is required, proceed as follows: Divide the ampere feet by 10 and then refer to column of Actual Volts Lost divided by 10, from which we find the size wire as before. For examples worked out to illustrate the use of the above table see pages 69 to 71.

* Rubber insulation. For carrying capacity of weatherproof insulated wires. See table on page 81, fourth column.

and you will see a vertical column headed "Volts." Go down this column until you come to 220 and follow the horizontal column to the right until you come to the figure 1.8 which is the nearest we can come to a 2 per cent. loss without a greater loss or "drop." Place your pencil on a figure 1.8 and follow down the vertical column of figures until you come to the nearest corresponding figure to 6,000, which we find to be 6,200. Then with your pencil on this figure follow the horizontal column to the left and we find that a No. 5 B. & S. wire is a proper size to use for the above conditions.

3. Supposing we have occasion to inspect a piece of wiring, and find a dynamo operating 50-50 watt 110-volt lamps at a distance of 150 feet, and our wire gauge shows that wire in use is a No. 12 B. & S., at what loss, or "drop," are these lamps being operated? First multiply the amperes, which will be 22.75 (50-50 watt 110-volt lamps take 22.75 amperes (see table on page 115), by the distance, 150 feet and we get 3,412 ampere feet. As we find in use a No. 12 B. & S. wire we look for the vertical column headed "Size B. & S." and follow it down until we come to 12. With our pencil on the figure 12 we travel along the horizontal line to the right until we come to the nearest corresponding number to 3,412, which we find to be 3,050. Then starting at this number we travel up the vertical column and we find a loss of about 10 actual volts, or at an 8 per cent. loss, which would greatly reduce the candle-power or brilliancy of his lamps. A larger wire should, therefore, be used.

APPROXIMATE AMPERES PER TERMINAL FOR ALTERNATING CURRENT INDUCTION MOTORS.

For determining capacity of fuses, setting of circuit breakers, and sizes of wires in connection with tables on pages 30 and 31.

H.P. of	110 Volts			220 Volts			440 Volts			550 V.	1100 V.	2200 V.
Motor	1 Phase	2 Phase	3 Phase	1 Phase	2 Phase	3 Phase	1 Phase	2 Phase	3 Phase	3 Phase	3 Phase	3 Phase
½	6.6	3.3	3.7	3.4	1.7	1.8	1.8	.9	1			
1	12	6	6.5	6	3	3.2	3	1.5	1.6			
2	21	10.5	12	19	5	6	5.2	2.6	3	2.5		
3	30	15	17	15	7.5	9	7.5	3.8	4.5	3.5		
5	54	27	30	26	13	15	13	6.5	7.5	6		
7½				40	20	22	20	10	11	9		
10				50	25	29	25	12.5	14	11		
15				71	35	41	36	18	20	16		
20				98	48	55	49	24	27	22		
25				110	54	62	56	27	31	25		
30				150	70	81		35	40	32	16	8
40				198	95	109		47	54	44	21	11
50				230	110	127		55	64	52	27	18
75					165	192		83	96	77	39	20
100					215	248		108	124	100	50	25
150					320	366		160	183	147	80	46
200					410	475		205	237	192	98	49
250					515	590		250	290	237	125	62
300					600	700		300	350	285	150	74

If the motor to be used does not come under **this** table the amperes per phase can easily be obtained from the manufacturer.

This table allows for Power Factor and efficiency, and no further calculations are necessary.

Wiring Calculations for Alternating Current. When figuring wire sizes for Alternating Current, except in cases of long distances, the following methods of calculating should be used.

As compared with the circular mileage of each conductor of a two wire system, that of each conductor of other systems, transmitting same power with the same distance, volts lost, and lamp voltage is, for:—

3 wire, single phase..............25.0%
4 wire, single phase..............11.1%
4 wire, two phase..................50.0%
3 wire, two phase..................50.0% with
middle wire ....75 %
4 wire, three phase, with neutral..16.6%
3 wire, three phase..............50.0%

All wires of each system; except 3 wire two phase; considered of same size.

We will now take an example in each system and show how to calculate the wire size.

Three Phase, Three Wire. What size wire should we use to run 1-220 volt, 30 horsepower induction motor; and light 102-220 volt, 60 watt mazda lamps; a distance of 400 feet to the center of distribution with the loss of 7 volts?

Let us refer to the table on page 72. Here we see that the amperes per phase (same as amperes per terminal) of a 3 phase, 220 volt, 30 H.P. motor is 81. We must calculate the amperes per phase for the lamps by using this formula:—

$$\text{Amperes} = \frac{\text{total watts of lamps}}{1.73 \times \text{volts}}$$

WIRING TABLE FOR LIGHT AND POWER—THREE PHASE, THREE WIRE.

For Three Phase, Four Wire, See Page 77.

Multiply current in amperes per phase by single distanceand refer to the nearest number under column of Actual Volts Lost, to find size of wire.

Carrying Capacity *Amperes	Size B. & S.	Actual Volts Lost. 25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
210	0000	286000	256000	227000	171000	114000	102000	91100	80000	68200	57000	45700	34200	22700	11400
177	000	266000	204000	181500	135200	90500	81500	72200	63200	54300	45200	36200	27200	18150	9050
150	00	179200	161300	144000	107000	71800	64300	57200	50200	42800	35800	28700	21600	14400	7180
127	0	142000	128000	113000	85200	57000	51200	45500	39800	34200	28300	22750	17090	11300	5700
107	1	110000	101500	905000	67700	45200	40500	36000	31600	27100	22600	18050	13540	9050	4520
90	2	89500	80800	71800	53700	35800	32300	28700	25000	21400	17900	14300	10800	7180	3580
76	3	71200	64000	56800	42650	28300	25500	22700	19900	17000	14200	11200	8520	5680	2830
65	4	55700	50700	45000	33700	22500	20250	18000	15760	13500	11200	9000	6750	4500	2250
54	5	44700	40200	35800	26800	17900	16100	14300	12360	10600	8950	7150	5370	3580	1790
46	6	35600	31800	28300	21300	14200	12700	11300	9900	8520	7100	5680	4270	2830	1420
33	8	22200	20000	17800	13330	8900	8000	7120	6220	5320	4450	3550	2660	1780	890
24	10	13950	12600	11000	8400	5590	5030	4480	3920	3360	2800	2240	1680	1100	559
17	12	8800	7910	7040	5285	3525	3170	2820	2470	2120	1760	1408	1040	704	352
12	14	5530	4980	4330	3330	2220	1993	1768	1552	1324	1110	886	664	433	222
6	16	3480	3140	2780	2090	1398	1255	1100	978	838	700	558	418	278	140

* Rubber covered, for weatherproof insulated wires, see page 81, fourth column.

In this case there are 102-60 watt lamps to be burned at 220 volts, therefore the

$$\text{Amperes per phase for lamps} = \frac{102 \times 60}{1.73 \times 220} = 16$$

Adding this to the 81 amperes for the motor we have $81 + 16 = 97$ for the total amperes per phase. Now let us look at the wiring table for three phase three wire circuits on page 74. It says at the top of this page "multiply current in amperes per phase by single distance (in feet) and refer to the nearest number under column of Actual Volts Lost, to find size of wire." Following these directions:—

$97 \times 400 = 38{,}800$; under column of 7 volts lost, the nearest number is 39,800, and following horizontally to the left, under column headed "Size B. & S." we find that No. 0 wire is our size, and since the allowable carrying capacity is 127 amperes, this size is permissible.

Two Phase, Three Wire. What size wire should we use to run 50-40 watt tungsten lamps and 1-10 H.P. induction motor, 220 volt service, a distance of 100 feet from the center of distribution, with a loss of 3 volts? There will be 25 lamps per phase and from the table on page 115 we find that the current taken by a 40 watt, 220 volt tungsten lamp is .1818 amperes; 25 of these lamps takes $25 \times .1818 = 9.09$ amperes. Referring to the table on page 72 we note that the amperes per phase of a 10 H.P., 220 volt, 2 phase motor is 25. This, then, gives us a total of $25 + 9.09 = 34.09$ amperes per phase.

WIRING TABLE FOR LIGHT AND POWER—TWO PHASE, THREE WIRE.

For Two Phase, Four Wires, See Page 70.

Multiply current in amperes per phase by single distance and refer to the nearest number under column of Actual Volts Lost to find size of wire.

apacity arrying Amperes utside Vires	Size B. & S. Outside Wires	Size B. & S. Middle Wire	Actual Volts Lost. 25	22.5	20	15	10	9	8	7	6	5	4	3	2	1
225	0000	300000C.M.	247000	222300	197600	148200	98800	88920	79040	69160	59280	49400	39520	29640	19760	9880
175	000	250000C.M.	196000	176400	156800	117600	78400	70560	62720	54880	47040	39200	31360	23520	15680	7840
150	00	0000	155375	139837	124300	93225	62150	55935	49720	43505	37290	31075	24860	18645	12430	6215
125	0	000	123250	110925	98600	73950	49300	44370	39440	34510	29580	24650	19720	14790	9860	4930
100	1	00	97750	97975	78200	58650	39100	35190	31280	27370	23460	19550	15640	11730	7820	3910
90	2	0	77500	69750	62000	46500	31000	27900	24800	21700	18600	15500	12400	9300	6200	3100
80	3	1	61500	55350	49200	36900	24600	22140	19680	17220	14760	12300	9840	7380	4920	2460
70	4	2	48750	43875	39000	29250	19500	17550	15600	13650	11700	9750	7800	5850	3900	1950
55	5	3	38750	34875	31000	23250	15500	13950	12400	10850	9300	7750	6200	4650	3100	1550
50	6	4	30750	27675	24600	18450	12300	11070	9840	8610	7380	6150	4920	3690	2460	1230
35	8	6	19275	17347	15420	11565	7710	6939	6168	5397	4626	3855	3084	2313	1542	771
25	10	8	12125	10912	9700	7275	4850	4365	3880	3395	2910	2425	1940	1455	970	485
20	12	10	7625	6862	6100	4575	3050	2745	2440	2135	1830	1525	1220	915	610	305
15	14	12	4800	4320	3840	2880	1920	1728	1536	1344	1152	960	768	576	384	192

NOTE.—In case a larger loss than any given in the table is required, proceed as follows:—Divide the ampere feet by 10 and then refer to column of Actual Volts Lost divided by 10, from which we find the size wire as before. For examples worked out to illustrate the use of the above table see page 75.

* Rubber insulation. For carrying capacity of weatherproof insulated wires. See page 81.

Turning to page 76 and following the directions given at the top of the table there given:—

$$34.09 \times 100 = 3409;$$

under the column of 3 volts loss, we find opposite the nearest number (3690) that we are to use No. 6 wire for the two outside lines and No. 4 wire for the middle one.

Two Phase, Four Wire. For this system of wiring calculate the amperes per phase the same as for 2 phase, three wire, and use the table on page 70 to find the size of wire. In the above problem under 2 phase, three wire, if we were to run a 2 phase, four wire service, we would use No. 6 wire for each line.

Three Phase, Four Wire, With Neutral. This system is very little used and therefore no table is given, but the sizes can be calculated in this way:— Calculate the circular mils necessary for a two wire system of the same total wattage, distance, volts lost and applied voltage and take as size for each wire 16.1%. For example, a system using a total of 10,000 watt, at 220 volts, 500 feet, and 10 volt drop, circular mils for two wire system =

$$\frac{10.8 \times 2 \times 500 \times 45.5}{10}$$

(formula given on page 160) = 49,000. 16.1% of this is 49,000 × .161 = 8,170. From table on page 74 we find that the nearest size (larger) is No. 10 wire, therefore we must use four wires of this size.

Single Phase, Two Wire. Calculate for this the same as for two wire D. C., using the table on page

70. In the case of motors, obtain the amperes required from table on page 72.

Single Phase, Three Wire. Calculate the size necessary for a two wire system of same power, voltage, volts lost, and distance, and take three wires of one-quarter the size thus calculated for this system. The same general method as given above under Three Phase, Four Wire.

Single Phase, Four Wire. Calculate the size necessary for a two wire system of same power, voltage, volts lost, and distance, and take 11.1% of the result for each wire in this system. The same general method as given above under Three Phase, Four Wire.

A convenient type of pocket wire gauge, one-half actual size, for measuring wire from No. 18 to No. 000 B. & S. gauge. On the front is given the safe carrying capacity of copper wires in amperes, and on the reverse side the approximate decimal equivalent of the various sizes of wires.

Installation of Wires. All wiring, when not enclosed in approved conduit, moulding or armored cable, should be kept free from contact with gas, water or other metallic piping, or any other conductors or conducting material which they may cross, by some continuous and firmly fixed non-conductor, creating a separation of at least two inches, and in wet places should be arranged so that an air space will be left between conductors and pipes in crossing, and the former should be run in such a way that they cannot come in contact with the pipe accidentally. Where one wire crosses another wire the best and usual means of separating them is by a porcelain tube on one of the wires. The tubing should be prevented from moving out of place either by a cleat or knob on each end, or by taping it.

The same method may be adopted where wires pass close to iron pipes, beams, etc., or, where the wires are above the pipes, as is generally the case, ample protection can frequently be secured by supporting the wires with a porcelain cleat placed as nearly above the pipe as possible.

Wires should be run over rather than under pipes upon which moisture is likely to gather, or which by leaking might cause trouble on a circuit. No smaller size than No. 14 B. & S. gauge should ever be used for any lighting or power work, not that it may not be electrically large enough but on account of its mechanical weakness and liability to be stretched or broken in the ordinary course of usage. Smaller wire may be used for fixture work, if provided with approved rubber insulation.

Wires should never be laid in or come in contact

with plaster, cement or any finish, and should never be fastened by staples, even temporarily, but always supported on porcelain or glass insulators or cleats which will separate the wires at least one-half inch from the surface wired over and keep the wires not less than two and one-half inches apart; three wire cleats may be used when the neutral wire is run in the center and at least two and one-half inches separate the two outside or + and — wires. This style of wiring is intended for low voltage systems (300 volts or less), and when it is all open work, rubber covered wire is not necessary as "weatherproof" wire may be used. Weatherproof wire should not be used in moulding. Wires should not be fished between floors, walls or partitions or in concealed places.

Twin wires should never be used, except in conduits; they are always unsafe for light or power circuits on account of the short distance between them.

All wiring should be protected on side walls from mechanical injury. This may be done by putting a substantial boxing about the wires, allowing an air space of one inch around the conductors and closed at the top (the wire passing through bushed holes) and the boxing extending about five feet above the floor. Sections of metal conduit may be used (the wire being protected by approved flexible tubing), and in most cases this practice is preferable. All bushings should be made of non-combustible, non-absorptive insulating material such as glass or porcelain and should be used wherever wires go through walls, floors, timbers or partitions. They

CARRYING CAPACITIES AND DIMENSIONS OF WIRES AND CABLES.

As adopted by the National Board of Fire Underwriters of the United States.

For further dimensions of bare and insulated wires, see Index.

Gauge No. B. & S.	Diameter Mils	Area Circular Mils	No. Amperes Weatherproof Insulation	No. Amperes Rubber Covered	Ohms Per 1000 Ft. (68° F.)	Lbs. Per 1000 Feet Bare	Feet Per Lb. Bare
18.....	40	1 624	5	3	6.385	4.9	203.40
16.....	51	2 583	10	6	4.016	7.8	127.90
14.....	64	4 107	20	15	2.525	12.4	80.44
12.....	81	6 530	25	20	1.588	19.7	50.59
10.....	102	10 380	30	25	.999	31.4	31.82
8.....	128	16 510	50	35	.628	49.9	20.01
6.....	162	26 250	70	50	.395	79.4	12.58
5.....	182	33 100	80	55	.313	100.2	9.98
4.....	204	41 740	90	70	.248	126.4	7.91
3.....	229	52 630	100	80	.197	159.3	6.27
2.....	258	66 370	125	90	.156	200.9	4.97
1.....	289	83 690	150	100	.124	253.3	3.94
0.....	325	105 500	200	125	.098	319.5	3.13
00.....	365	133 100	225	150	.077	402.8	2.48
000.....	410	167 800	275	175	.062	507.9	1.96
0000.....	460	211 600	325	225	.049	640.9	1.56
Cables...	450	200 000	300	200	.0532	800	
" ...	630	300 000	400	275	.0335	932	For weights of insulated wires, see pages 205-209.
" ...	727	400 000	500	325	.0251	1242	
" ...	814	500 000	600	400	.0201	1553	
" ...	892	600 000	680	450	.0166	1863	
" ...	964	700 000	760	500	.0143	2174	
" ...	1030	800 000	840	550	.0125	2474	
" ...	1092	900 000	920	600	.0111	2795	
" ...	1152	1 000 000	1000	650	.0100	3106	
" ...	1209	1 100 000	1080	690	.0091	3416	
" ...	1263	1 200 000	1150	730	.0083	3727	
" ...	1314	1 300 000	1220	770	.0076	4038	
" ...	1364	1 400 000	1290	810	.0071	4348	
" ...	1413	1 500 000	1360	850	.0066	4658	
" ...	1459	1 600 000	1430	890	.0062	4968	
" ...	1504	1 700 000	1490	930	.0058	5278	
" ...	1548	1 800 000	1550	970	.0055	5588	
" ...	1572	1 900 000	1610	1010	.0052	5898	
" ...	1630	2 000 000	1670	1050	.0050	6208	

The lower current carrying limit (fifth column) is specified for rubber-covered wires to prevent gradual deterioration of the high insulations by the heat of the wires, but not from fear of igniting the insulation.

The carrying capacity of Nos. 18 and 16 B. & S. gauge wire is given, but no smaller than No. 14 should be used for general wiring purposes.

TENSILE STRENGTH OF COPPER WIRE.

Numbers, B. & S. G.	Breaking weight, Pounds. Hard-drawn.	Breaking weight, Pounds. Annealed.	Numbers, B. & S. G.	Breaking weight, Pounds. Hard-drawn.	Breaking weight, Pounds. Annealed
0 000	8 310	5 650	9	616	349
000	6 580	4 480	10	489	277
00	5 226	3 553	11	388	219
0	4 558	2 818	12	307	174
1	3 746	2 234	13	244	138
2	3 127	1 772	14	193	109
3	2 480	1 405	15	153	87
4	1 967	1 114	16	133	69
5	1 559	883	17	97	55
6	1 237	700	18	77	43
7	980	555	19	61	34
8	778	440	20	48	27

The strength of soft copper wire varies from 32,000 to 36,000 pounds per square inch, and of hard copper wire from 45,000 to 68,000 pounds per square inch, according to the degree of hardness.

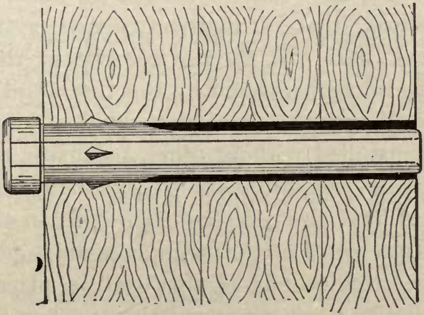
EQUIVALENT CROSS SECTIONS OF WIRES.

Brown & Sharp Gauge.

0000	2—0	4—3	8—6	16—9	32—12	64—15	128—18
000	2—1	4—4	8—7	16—10	32—13	64—16	......
00	2—2	4—5	8—8	16—11	32—14	64—17	1 and 3
0	2—3	4—6	8—9	16—12	32—15	64—18	2 " 4
1	2—4	4—7	8—10	16—13	32—16	......	3 " 5
2	2—5	4—8	8—11	16—14	32—17	......	4 " 6
3	2—6	4—9	8—12	16—15	32—18	......	5 " 7
4	2—7	4—10	8—13	16—16	......	......	6 " 8
5	2—8	4—11	8—14	16—17	......	......	7 " 9
6	2—9	4—12	8—15	16—18	......	......	8 " 10
7	2—10	4—13	8—16	......	......	......	9 " 11
8	2—11	4—14	8—17	......	......	......	10 " 12
9	2—12	4—15	8—18	......	......	......	11 " 13
10	2—13	4—16	.....	......	......	......	12 " 14
11	2—14	4—17	.....	......	......	......	13 " 15
12	2—15	4—18	.....	......	......	......	14 " 16
13	2—16	.....	.....	......	......	......	15 " 17
14	2—17	.....	.....	......	......	......	16 " 18
15	2—18	.....	.....	......	......	......	....

should be long enough to bush the entire length of the hole in one continuous piece, or else the hole must first be bushed by a continuous waterproof tube. This tube may be a conductor, such as iron pipe, but in that case the wire must be protected by *approved* flexible tubing extending far enough to keep the wire absolutely out of contact with the pipe.

If, however, iron pipes are used with alternating currents, the two or more wires of a circuit should



Porcelain Insulating Tube for partition and walls.

always be placed in the same conduit. If plain iron pipe be used the insulation of that portion of each wire within the pipe should be reinforced by a tough *approved* flexible tubing projecting beyond the iron tubing.

When crossing floor timbers in cellars or in rooms when they might be exposed to injury, wires should be attached, by their insulating supports, to the under side of wooden strips not less than one-half inch in thickness and not less than three inches wide.

When wires are run immediately under roofs, or in proximity to water tanks or pipes they will be considered as exposed to moisture and care should be taken as described on pages 87 and 103.

SWITCHES, CUT-OUTS, CIRCUIT-BREAKERS, ETC.

On constant potential circuits, all service switches and all switches controlling circuits supplying current to motors or heating devices, and all fuses should be so arranged that the fuses will protect and the opening of the switch will disconnect all of the wires; that is, in the two-wire system the two wires, and the three-wire system the three wires, should be protected by the fuses and disconnected by the operation of the switch.

When installed without other automatic overload protective devices automatic overload circuit breakers should have the poles and trip coils so arranged as to afford complete protection against overloads and short circuits, and if also used in place of the switch should be so arranged that no one pole can be opened manually without disconnecting all the wires.

This, of course, does not apply to the grounded circuit of street railway systems.

They should not be placed where exposed to mechanical injury nor in the immediate vicinity of easily ignitible stuff or where exposed to inflammable gases or dust or to flyings of combustible material.

Where the occupancy of a building is such that switches, cut-outs, etc., cannot be located so as not to be exposed as above, they should be enclosed

in approved dust-proof cabinets with self-closing doors, except oil switches and circuit breakers which have dust-tight casings.

They should also, when exposed to dampness, either be enclosed in a moisture-proof box or mounted on porcelain knobs. The cover of the box should be so made that no moisture which may collect on the top or sides of the box can enter it.

Time switches, sign flashers and similar appliances should be of approved design and enclosed in *approved* cabinets.

Series Arc Lamp Wiring. All wiring in buildings for constant current series arc lighting should be with approved rubber covered wire and the circuit arranged to enter and leave the building through an approved double contact service switch, which means a switch mounted on a non-combustible, non-absorptive insulating base and capable of closing the main circuit and disconnecting the branch wires when turned "off"; this switch must be so constructed that it will be automatic in action, not stopping between points when started, and must prevent an arc between points under all circumstances, and must indicate, upon inspection, whether the current be "on" or "off." Such a switch is necessary to cut the high voltage current completely out of the building by firemen in case of fire or when it becomes necessary to make any changes in the lamps or wiring. It should be in a non-combustible case.

This class of wiring should never be concealed or incased except when requested by the Electrical Inspector, and should always be rigidly supported

on porcelain or glass insulators which will separate the wiring at least one inch from the surface wired over, and should be kept at least eight inches from each other. No wires carrying a potential of over 3,500 volts should be carried into or over any building except central stations and sub-stations. All arc light wiring should, on side walls, be protected from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than seven feet from the floor. When crossing floor timbers in cellars, or in rooms where they might be exposed to injury, wires should be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness. Instead of the running-boards, guard strips on each side of and close to the wires will be sufficient. These strips to be not less than seven-eighths of an inch in thickness and at least as high as the insulators.

Except on joisted ceilings, a strip one-half of an inch thick is not considered sufficiently stiff and strong. For spans of say eight or ten feet, where there is but little vibration, one-inch stock is generally sufficiently stiff; but where the span is longer than this or there is considerable vibration, still heavier stock should be used.

Series arc lamps should be isolated from inflammable material, and should be provided at all times with a glass globe surrounding the arc, and securely fastened upon a closed base. Broken or cracked globes should not be used.

They should be provided with a wire netting (having a mesh not exceeding one and one-fourth inches) around the globe, and an *approved* spark arrester when readily inflammable material is in the vicinity of the lamps, to prevent escape of sparks of carbon or melted copper. It is recommended that plain carbons, not copper-plated, be used for lamps in such places.

Outside arc lamps should be suspended at least eight feet above sidewalks. Inside arc lamps should be placed out of reach or suitably protected.

Arc lamps, when used in places where they are exposed to flyings or easily inflammable material, should have the carbons enclosed completely in a tight globe in such manner as to avoid the necessity for spark arresters.

"Enclosed arc" lamps, having tight inner globes, may be used in such places.

SERIES INCANDESCENT LAMP WIRING.

The same suggestions given for the wiring for series arc lamps should apply to this class of work as well. Each series incandescent lamp should be provided with its own automatic cut-out. Each lamp should be suspended from a hanger-board by a rigid tube.

In no way should they come in contact with, or be connected to, gas fixtures. No electro-magnetic device for switches and no multiple-series or series-multiple systems of lighting should be used.

Special Wiring for damp places such as breweries, packing houses, stables, dye houses, paper or pulp mills, or buildings specially liable to moisture or acid or other fumes liable to injure the wires or

their insulation, except where used for pendants should always be done with approved rubber covered wire, and rigidly supported on porcelain or glass insulators which separate the wires at least one inch from the surface wired over and must be kept apart at least two and one-half inches. The wire in such damp places should contain no splices as it is almost impossible to tape a splice that will prevent acid fumes from getting at the copper surface.

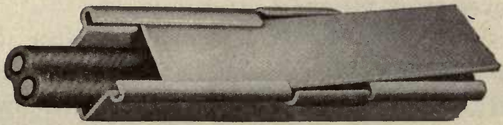
Wood Moulding Work should always be done with approved rubber-covered wire to prevent leakage should the moulding become damp.

This class of work should never be done in concealed or damp places for fear that water may soak into the wood and cause leakage of current between the wires, burning the wood and starting a fire. The action of the current in a case like this is to very gradually convert the wood into charcoal, then dry the water out and ignite the charcoal thus formed. Great care should be observed in driving nails into moulding in order to avoid puncturing the insulation, and possibly grounding the circuit in a way that would not only be difficult to locate, but might cause a concealed fire back of the plastering or wood work to which the moulding is attached.

Wood Moulding should be made of hard wood and should be made of two pieces, a backing and capping, so constructed as to thoroughly encase the wire. It should provide a one-half inch tongue between the conductors and a solid backing, which under the grooves should not be less than three-eighths of an inch and on the sides not less than

one-fourth of an inch in thickness and be able to give suitable protection from abrasion. All wood mouldings should be painted with two coats of waterproof material or impregnated with a moisture repellant. Wood moulding should never be used in damp places.

Metal Moulding should be of approved make, should be constructed of iron or steel with backing at least .050 inch in thickness, and with capping not less han .040 inch in thickness, and so constructed that when in place the raceway will be entirely



Metal Moulding.

closed, and be thoroughly galvanized or coated with an approved rust preventative both inside and out to prevent oxidation. Each length of metal moulding should have the maker's name or trade mark stamped in the metal, and only *approved* moulding should be used.

Elbows, couplings and all other similar fittings should be constructed of at least the same thickness and quality of metal as the moulding itself, and so designed that they will both electrically and mechanically secure the different sections together and

maintain the continuity of the raceway. The interior surfaces should be free from burrs or sharp corners which might cause abrasion of the wire coverings.

All outlets should be so arranged that the conductors cannot come in contact with the edges of the metal, either of capping or backing. Specially designed fittings which will interpose substantial barriers between conductors and the edges of metal are recommended.

When backing is secured in position by screws or bolts from the inside of the raceway, depressions should be provided to render the heads of the fastenings flush with the moulding.

Metal mouldings should be so constructed as to form an open raceway to be closed by the capping or cover after the wires are laid in.

No moulding work, with either metal or wood, should ever be done in damp or concealed places, or when the difference of potential between any two wires in the same moulding is over 300 volts; metal mouldings should not be used for circuits requiring more than 1,320 watts of energy. Alternating current circuits should have their two or more wires run in the same metal moulding for inductive reasons.

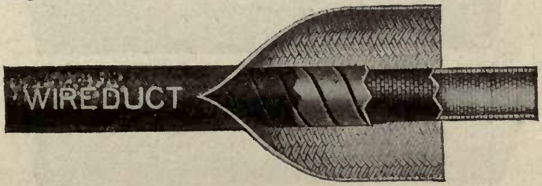
Concealed Wiring or that which is to be run between walls and floors and through joists, should always be done with approved rubber-covered wire, and should be rigidly supported on porcelain or glass insulators which will separate the wires at least one inch from the surface wired over, and the wires kept at least five inches apart, and where it is

possible wires should be run singly on separate timbers or joists.

The wires should be separated from contact with the walls, floor timbers and partitions through which they may pass by non-combustible, non-absorptive insulating tubes, such as glass or porcelain.

Rigid supporting requires, under ordinary conditions, where wiring along flat surface, supports at least every four and one-half feet. If the wires are liable to be disturbed the distance between supports should be shortened.

At distributing centers, outlets or switches where space is limited and the five-inch separations cannot be maintained, each wire should be separately encased in a continuous length of approved flexible tubing.



Approved Flexible Tubing.

Wires passing through timbers at the bottom of plastered partitions should be protected by an additional tube extending at least four inches above the timber.

When in a concealed knob and tube system, it is impracticable to place the whole of a circuit on non-combustible supports of glass or porcelain, that portion of the circuit which cannot be so supported should be installed with *approved* metal conduit, or *approved* armored cable except that if the difference of potential between the wires is not over 300 volts, and if the wires are not exposed to moisture, they may be fished if separately encased in approved flexible tubing, extending in continuous lengths from porcelain support to porcelain support, from porcelain support to outlet, or from outlet to outlet.

Wires should at all outlets, except where conduit

is used, be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support to at least one inch beyond the outlet. In the case of combination fixtures the tubes should extend at least flush with outer end of gas cap.

It is recommended that *approved* outlet boxes or plates be installed at all outlets in concealed "knob and tube" work, the wires to be protected by *approved* flexible tubing, extending in continuous lengths from the last porcelain support into the box.

METAL CONDUIT (RIGID).

Every length of approved metal conduit (ten feet) has the maker's name or initials stamped in the metal. Metal conduit is made of mild steel and

Approved Metal Conduits.

is coated with enamel or rust resisting material.

The standard lengths, ten feet each, are furnished in fifteen diameters as follows: ¼, ⅜, ½, ¾, 1, 1¼, 1½, 2, 2½, 3, 3½, 4, 4½, 5 and 6 inches. Each size has its corresponding size elbow, coupling, etc. The specifications for the construction of metal conduit are numerous, but the contractor or wireman need not bother about these details—just see that it is of the proper size and bears the name or initials of an approved maker.

Flexible Steel Conduit is made for use on odd or irregular bends or for inaccessible places where the rigid conduit could only be installed with great difficulty. It is furnished in any lengths desired and in nine different diameters (inside), 5/16, ⅜, ½, ¾, 1, 1¼, 1½, 2 and 2½ inches.

No metal conduit with an inside diameter of less than one-half inch should be used. All conduit work should be continuous from outlet to outlet or to junction boxes or cabinets, and the conduit should properly enter, and be secured to all fittings, and the entire system mechanically secured in position.

In case of service connections and main runs, this involves running each conduit continuously into a main cut-out cabinet or gutter surrounding the panel board, as the case may be.

It should be first installed as a complete conduit system, without the conductors.

It should be equipped at every outlet with an *approved* outlet box or plate. At exposed ends of conduit (but not at fixture outlets) where wires pass from the conduit system without splice, joint or tap, an approved fitting having separately bushed holes for each conductor should be used.

Outlet plates should not be used where it is practicable to install outlet boxes.

For concealed work in walls and ceilings composed of plaster on wooden joists or stud construc-

tion, outlet boxes or plates and also cut-out cabinets should be so installed that that the front edge will not be more than one-fourth inch back of the finished surface of the plaster, and if this surface is broken or incomplete it should be repaired so that it will not show any gaps or open spaces around the edges of the outlet box or plate or of the cut-out cabinet. On wooden walls or ceilings, outlet boxes or plates and cut-out cabinets should be so installed that the front edge will either be flush with the finished surface or project therefrom. This will not apply to concealed work in walls or ceilings composed of concrete, tile or other non-combustibile material.

In buildings already constructed where the conditions are such that neither outlet box nor plate can be installed, these appliances may be omitted, providing the conduit ends are bushed and secured.

It is suggested that outlet boxes and fittings having conductive coatings be used in order to secure better electrical contact at all points throughout the conduit system.

Metal conduits where they enter junction boxes, and at all other outlets, etc., should be provided with *approved* bushings or fastening plates fitted so as to protect wire from abrasion, except when such protection is obtained by the use of *approved* nipples, properly fitted in boxes or devices.

The metal of the conduit should be permanently and effectually grounded to water piping, gas piping or other suitable grounds, provided that when connections are made to gas piping, they are on the street side of the meter. If the conduit system

consists of several separate sections, the sections should be bonded to each other, and the system grounded, or each section may be separately grounded, as required above. Where short sections of conduit (or pipe of equivalent strength) are used for the protection of exposed wiring on side walls, the conduit or pipe need not be grounded.

Conduits and gas pipes should be securely fastened in outlet boxes, junction boxes and cabinets, so as to secure good electrical connections.

If conduit, couplings, outlet boxes, junction boxes, cabinets or fittings, having protective coating of non-conducting material such as enamel are used, such coating should be thoroughly removed from threads of both couplings and conduit, and such surfaces of boxes, cabinets and fittings where the conduit or ground clamp is secured in order to obtain the requisite good connection. Grounded pipes should be cleaned of rust, scale, etc., at place of attachment of ground clamp.

Connections to grounded pipes and to conduit should be exposed to view or readily accessible, and should be made by means of approved ground clamps to which the ground wires should be soldered.

Ground wires should be of copper, at least No. 10 B. & S. gage (where largest wire contained in conduit is not greater than No. 0 B. & S. gage), and need not be greater than No. 4 B. & S. gage (where largest wire contained in conduit is greater than No. 0 B. & S. gage). They should be protected from mechanical injury.

All elbows or bends should be so made that the

conduit will not be injured. The radius of the curve of the inner edge of any elbow not to be less than three and one-half inches. There should be not more than the equivalent of four quarter bends from outlet to outlet, the bends at the outlets not being counted.

CONDUIT WIRING.

All conductors for this class of work should be approved rubber covered.

Single wire for conduits must comply with the requirements and in addition there should be a second outer fibrous covering, at least one thirty-second of an inch in thickness for wires larger than No. 10 B. & S. gage, and at least one sixty-fourth of an inch in thickness for wires No. 10 B. & S. gage or less in size; this fibrous covering to be sufficiently tenacious to withstand abrasion of being hauled through the metal conduit.

For twin or duplex wires in conduit each conductor must comply with requirements and in addition there must be a second outer fibrous covering, at least one thirty-second of an inch in thickness for wires larger than No. 10 B. & S. gage, and at least one sixty-fourth of an inch in thickness for wires No. 10 B. & S. gage or less in size; this fibrous covering to be sufficiently tenacious to withstand abrasion of being hauled through the metal conduit.

For concentric wire, the inner conductor should comply with the requirements and there should be outside of the outer conductor the same insulation as on the inner, the whole to be covered with a substantial braid, which should be at least one thirty-

second of an inch in thickness, and sufficiently tenacious to withstand the abrasion of being hauled through the metal conduit.

The braids or tapes should be properly saturated with a preservative compound.

The braid or tape required around each conductor in duplex, twin and concentric cables is to hold the rubber insulation in place and prevent jamming and flattening. No wires should be drawn into conduits until all mechanical work on the building has been done.

Conductors in vertical conduit risers should be supported within the conduit system in accordance with the following table:

No. 14 to 0 every 100 feet.

No. 00 to 0000 every 80 feet.

0000 to 350,000 C. M. every 60 feet.

350,000 C. M. to 500,000 C. M. every 50 feet.

500,000 C. M. to 750,000 C. M. every 40 feet.

750,000 C. M. every 35 feet.

The following methods of supporting cables are recommended:

1. A turn of 90 degrees in the conduit system will constitute a satisfactory support.

2. Junction boxes may be inserted in the conduit system at the required intervals, in which insulating supports of *approved* type must be installed and secured in a satisfactory manner so as to withstand the weight of the conductors attached thereto, the boxes to be provided with proper covers.

3. Cables may be supported in *approved* junction boxes on two or more insulating supports so placed that the conductors will be deflected at an

angle of not less than 90 degrees, and carried a distance of not less than twice the diameter of the cable from its vertical position. Cables so suspended may be additionally secured to these insulators by tie wires.

For alternating systems, the two or more wires of a circuit should be drawn in the same conduit.

It is suggested that this be done for direct current systems also, so that they may be changed to alternating systems at any time, induction troubles preventing such a change if the wires are in separate conduits.

Fixtures should, when supported from the gas piping of a building, be insulated from the gas pipe system by means of approved insulating joints (see page 107) placed as close as possible to the ceiling, and the wires near the gas pipe above the insulating joint should be protected from possible contact by the use of porcelain tubes.

All burrs or fins should be removed from the fixtures before the wires are drawn in. The tendency to condensation within the pipes should be guarded against by sealing the upper end of the fixture.

In combination fixtures, where the wiring is concealed between the inside pipe and outer casing, the space between pipe and casing should be at least a quarter of an inch to allow plenty of room for the insulation of the wires without jamming.

Fixtures should be tested for "contacts" between conductors and fixtures, for "short-circuits" and for ground connections before it is connected to its supply conductors.

Ceiling blocks of fixtures should be made of in-

sulating material; if not, the wires in passing through the plate should be surrounded by porcelain tubes, which should extend below the insulating joint.

When fixtures have canopies against plaster in fireproof buildings, or where wire lath or metal ceiling or metal wall finish is used, the canopies should be thoroughly and permanently insulated from such walls or ceilings by approved canopy insulators. (See illustration on page 107.)

Rosettes. These fittings should not be located where inflammable flyings or dust will accumulate on them. Bases should be high enough to keep the wires and terminals at least one-half inch from the surface to which the rosette is attached.

Terminals with a turned up lug to hold the wire or cord should be used, and in no case must the wire be cut or injured. Fused rosettes are not advised for use where cords can be properly protected by line cut-outs, and where necessary those equipped with *enclosed* fuses are recommended. If fused rosettes are used the next fuses back should not be over 25 amperes capacity.

Fixture Wiring should be done with approved fixture wire. The voltage should never exceed 300 on wires in fixtures.

Although No. 18 "rubber covered" is allowable in fixture work, it is preferable to use nothing smaller than No. 16, if practicable, for mechanical reasons. Supply conductors, and especially the splices to fixture wires, should be kept clear of the grounded part of gas pipes, and where shells are used the latter should have area enough to prevent

pressing the wires against the gas pipe when finally in place.

Flexible Cord should be made of stranded copper conductors, no single strand should be larger than No. 26 or smaller than No. 36 (B. & S. gauge) and each conductor should be covered by an approved insulation and be protected from mechanical injury by a tough braided outer covering. When used for pendant lamps it should hang freely in air and so placed that there is no chance of its coming in contact with anything excepting the lamp socket to which it is attached and the rosette from which it hangs. Each stranded conductor should have a carrying capacity equivalent to not less than a No. 18 (B. & S. gauge) wire. The covering of the stranded wires for flexible cord should first have a tight, close wind of fine cotton, which is intended to prevent any broken strand from piercing the insulation and causing a short circuit or ground. Secondly it should have a solid waterproof insulation at least one thirty-second of an inch thick. The outer protecting braiding should be so put on and sealed in place that when cut it will not fray out.

Approved flexible cord may be had from any of the makers mentioned on pages 66 and 67.

Flexible cord should not be used as a support for clusters, as it is not strong enough, and it should never be used for anything other than pendants, wiring of fixtures and portable lamps, portable motors or small light electrical apparatus. Where used for "portables" it should have a special outer covering.

Flexible cord should never be used in show win-

dows, as a defective piece might cause a short circuit and set fire to flimsy material or decorations. Many fires have been caused by the use of flexible cord in show windows, where handkerchiefs, decorations, etc., have been pinned to the cord. When the current is "turned on" short circuits are caused by the pins, and a fire is the result. Armored cables, however, may be used for this class of work and are made by the following companies:

Boston Ins. Wire & Cable Co., Boston; Columbia Metal Hose Wks., Bayonne, N. J.; Eastern Flexible Conduit Co., Brooklyn, N. Y.; Flexible Conduit Co., Pen Yan, N. Y.; National Metal Molding Co., Pittsburg, Pa.; Pratt Chuck Co., Frankfort, N. Y.; Safety-Armorite Conduit Co., Pittsburg, Pa.; Sprague Electric Wks. of G. E. Co., New York; Trenton Electric & Conduit Co., Trenton, N. J.; Western Conduit Co., Youngstown, O.

Insulating bushings should be used where cords enter lamp sockets and desk stand lamps.

Flexible cord should be so suspended that the entire weight of the socket, lamp and shade will be borne by knots under the bushing in the socket, and above the point where the cord comes through the ceiling block or rosette, in order that the strain may be taken from the joints and binding screws. It is good practice to always solder the ends of flexible cords which are going under binding screws, as it holds the strands together and prevents the pressure of the screws from forcing the strands from under them, and against the shell of the socket, causing a ground on the shell, or short circuit.

Where it becomes necessary to solder a great number of ends, as may be required when wiring a factory, use a small pot of melted solder and dip the ends of the wire, which have all been previously cut to the proper length and fluxed with a good soldering paste or solution.

Standard Lamp Sockets should be plainly marked with the watts and volts which apply to their class and with either the manufacturer's name or registered trade mark. The inside of the shell of the socket should have an insulating lining which should absolutely prevent the shell from becoming a part of the circuit even though a wire or strand inside the socket should become loose or come out from under a binding screw. This insulating lining should be at least one-thirty-second of an inch thick and of a tough and tenacious material.

Special Lamp Sockets. In rooms where inflammable gases may exist, both the socket and lamp should be enclosed in a vapor-tight globe and supported on a pipe-hanger and wired with "Rubber Covered" wire, soldered directly to the circuit. No fuses or switches of any sort should be used in the room in such cases as the slightest arc might produce dangerous explosions or fires.

Waterproof Keyless Socket to be used in dye houses and damp places.

Splicing should be done as described on page 40, in fact all wires, for this class of work, should be joined in this thorough manner and soldered.

In damp or wet places, such as dye houses breweries, etc., a waterproof socket such as shown on page 91, should be used. Waterproof sockets should be hung by separate stranded rubber-covered wires, not smaller than No. 14 (B. & S.). These wires should be soldered direct to the circuit wires, but supported independently of them. All sockets for the above conditions should be keyless.

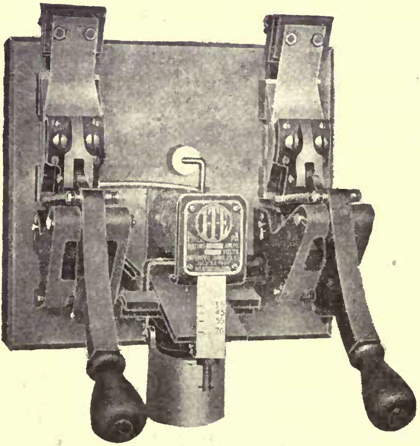
Stranded Wires in every case should be soldered together before being clamped under binding screws, and when they have a conductivity greater than No. 10 (B. & S.) copper wire, they should be soldered into lugs. Stranded wires if not thus stiffened before being clamped under binding posts are liable to be pressed out or easily worked loose, making a poor contact, which causes heating, a possibility of arcing or a complete burn out. Dossert approved solderless lugs may be used.

Automatic Cut-Outs such as circuit breakers and fuses should be placed on all service wires as near as possible to the point where they enter the building, on the inside of the walls, and arranged to cut off the entire current from the building.

The cut-out or circuit breaker should always be the first thing that the service wires are connected to after entering the building; the switch next, and then the other fixtures or devices in their order. This arrangement is made so that the cut-out or circuit-breaker will protect all wiring in the build-

ing, and the opening of the switch will disconnect all the wiring. (See cuts on pages 33-38.)

These automatic cut-outs should not, however, be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases or dust, or to flyings of combustible material, as the arcing produced whenever they break the circuit



Circuit Breaker.

The New I-T-E Circuit Breaker with Time Limit Feature.

might cause a fire or explosion. When they are exposed to dampness they should be inclosed in a waterproof box or mounted on porcelain knobs. All cut-outs and circuit-breakers should be supported on bases of non-combustible, non-absorptive insulating material. Link fuses should never be used, they are obsolete and have been the cause of

no end of fires and troubles. Enclosed fuses are always preferable.

Cut-outs should operate successfully under the most severe conditions they are liable to meet with in practice, on short circuits with fuses rated at 50 per cent. above, and with a voltage 25 per cent. above the current and voltage for which they are designed. Circuit breakers should also be designed to successfully operate under the severe conditions liable to be met with in practice, and when designed to carry less than 100 amperes must be able to operate successfully on a short circuit with a supply system having a capacity of 1,000 amperes. They must also stand 2,000 volts A. C. for one minute between ground and live metal parts. All cut-outs and circuit breakers should be plainly marked, and where it will always be visible, with the name of the maker, and current and voltage for which the device is designed.

Cut-outs or circuit breakers should be placed at every point where a change is made in the size of wire, unless such a device in the larger wire will protect the smaller. They should never be placed in canopies or shells of fixtures, but should be so placed that no set of incandescent lamps, whether grouped on one fixture or several fixtures or pendants, requiring more than 660 watts should be dependent upon one cut-out. Special permission may be given in writing by the Inspection Department having jurisdiction in case extra large or special chandeliers are to be used. Fuses for cut-outs should not have a capacity to exceed the carrying capacity of the wire, and where circuit breakers

are used they should not be set more than 30 per cent. above the allowable carrying capacity of the wire, unless a fusible cut-out is also installed in the circuit as shown in the illustration on page 33. Excepting on main switchboards, or where they are at all times subject to expert supervision, circuit breakers should never be used as a protection to a circuit without the additional use of enclosed fuse cut-outs.

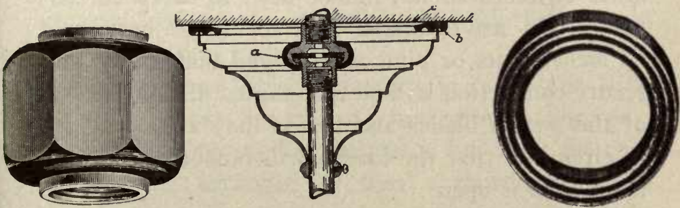
Circuit breakers open at exactly the current they are set for and instantly, therefore it is necessary to set them considerably above the ordinary amount of current required to keep them from constantly opening on slight fluctuations. When this is the case a double-pole fusible cut-out should be added to protect the wire from a heavy, steady current, which may be maintained just below the opening point of the circuit breaker. The fuse requires a little time to heat, and would not therefore blow out with a momentary rise of current which might open the circuit breaker if set as low as necessary to protect the wire, which may be of a size only large enough for the figured amount of current under ordinary conditions of operation. If, however, in the case of motor-wiring, the size of wire is 25 per cent. above the figured size for the motor's average current, as it should be, then the introduction of a fusible cut-out in addition to the circuit breaker is unnecessary, as is shown in the illustration on page 35.

Insulating Joints should be made entirely of material that will resist the action of illuminating gases, and will not give way or soften under the

heat of an ordinary gas flame, or leak under a moderate pressure and able to withstand 4,000 volts for five minutes.

They should be so arranged that a deposit of moisture will not destroy the insulating effect, and should have an insulation resistance of at least 250,000 ohms between the gas pipe attachments, and be sufficiently strong to resist the strain they will be liable to be subjected to in being installed.

Insulating joints should not contain any soft rubber in their composition. The insulating mate-



A B C

A Macallen Insulating Joint. B Macallen Canopy and Insulating Joint in Position. C Macallen Canopy Insulator

rial should be of some hard and durable material such as mica.

Insulating Resistance. The wiring in any building should test free from grounds, *i. e.*, the complete installation should have an insulation between conductors and between all conductors and the ground (not including attachments, sockets, receptacles, etc.) of not less than the following:

Up to	5	amperes	4,000,000	ohms.
"	10	"	2,000,000	"
"	25	"	 800,000	"

Up to	50 amperes	400,000	ohms.
"	100 "	200,000	"
"	200 "	100,000	"
"	400 "	 50,000	"
"	800 "	 25,000	"
"	1,600 "	and over... 12,500	"

Al cut-outs and safety devices in place in the above when the tests are made.

Where lamp sockets, receptacles and electroliers, etc., are connected, one-half of the above will be sufficient. (See page 51 for method.)

Knife Switches—(Specifications). Hinges of knife switches should not be used to carry current unless they are equipped with spring washers, held by locked nuts or pins so arranged that a firm and secure connection will be maintained at all positions of the switch blades and unless they are connected in circuit so that the blades will not be alive when the switch is open.

The bases of all switches should be made of non-combustible, non-absorptive insulating material, such as slate, marble or porcelain.

Switches for currents of over 30 amperes should be equipped with lugs firmly screwed or bolted to the switch and into which the conducting wires should be soldered. For the smaller size switches simple screws can be employed provided they are heavy enough to stand considerable hard usage. Holes for inserting screws for supporting the switch should not be placed between contacts of opposite polarity.

Pieces carrying the contact jaws should be secured to the base by at least two screws or else

made with a square shoulder or equipped with dowel pins to prevent possible turnings and the nuts or screw heads on the under side of the base should be countersunk not less than one-eighth inch and covered with a waterproof compound which will not melt below 150 degrees Fahrenheit.

All cross-bars less than three inches in length should be made of insulating material. Bars of three inches and over which are made of metal to insure greater mechanical strength should be sufficiently separated from the jaws of the switch to prevent arcs following from the contacts to the bar on the opening of the switch under any circumstances. Metal bars should preferably be covered with insulating material.

All switches should have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahrenheit at full load, the contacts being arranged so that a thoroughly good bearing at every point is obtained with contact surfaces advised for pure copper blades of about one square inch for each 75 amperes; the whole device should be mechanicaly well made throughout.

The following table shows minimum break distances and separation of nearest metal parts of opposite polarity for different voltages and different currents. The values given are correct for switches to be used on direct current systems and can therefore be safely followed in devices designed for alternating currents.

All switches should be plainly marked, where it can be read, when the switch is installed, with the name of the maker and the current and voltage for which the switch is designed.

	Minimum Separation of Nearest Metal Parts of Opposite Palarity.	Minimum Break Distance.
125 VOLTS OR LESS:		
For Switchboards and Panel Boards:—		
10 amperes or less	¾ inch	½ inch.
11-30 amperes	1 "	¾ "
60 "	1¼ "	1 "
For Individual Switches:—		
30 amperes	1¼ inch	1 inch.
60-100 "	1½ "	1¼ "
200-300 "	2¼ "	2 "
400-600 "	2¾ "	2½ "
800-1000 "	3 "	2¾ "
250 VOLTS D. C., AND NOT OVER 500 VOLTS A. C.:		
For all Switches:—		
31-100 amperes	2¼ inch	2 inch.
200-300 "	2½ "	2¼ "
400-600 "	2¾ "	2½ "
800-1000 "	3 "	2¾ "

A 300-ampere switch with the spacings of the 200-ampere switch above may be used on switchboards.

Cut out terminals on switches for over 250 volts must be designed and spaced for 600-volt fuses.

600 VOLTS:		
For all Switches:—		
30-60 amperes	4 inch	3½ inch.
100 "	4½ "	4 "

Auxiliary contacts of either a readily renewable or a quick-break type or the equivalent are recommended for D. C. switches, designed for over 250 volts, and should be provided on D. C. switches designed for use in breaking currents greater than 100 amperes at a voltage of over 250.

For 3-wire direct current and 3-wire single phase systems the separation and break distances for plain 3-pole knife switches should not be less than those required in the above table for switches designed for the voltage between neutral and outside wires.

Knife Switches (Installation). Switches should be placed on all service wires, either overhead or underground, in the nearest readily accessible place to the point where the wires enter the building, and arranged to cut off the entire current.

Service cut-out and switch should be arranged to cut off current from all devices including meters.

In risks having private plants the yard wires running from building to building are not considered as service wires, so that switches would not be required in each building if there are other switches conveniently located on the mains or if the generators are near at hand.

Switches should always be placed in dry, accessible places, and be grouped as far as possible. Single-throw knife switches should be so placed that gravity will not tend to close them. Double-throw knife switches may be mounted so that the throw will be either vertical or horizontal as preferred, but if the throw be vertical a locking device should be provided, so constructed as to insure the blades remaining in the open position when so set.

When practicable switches should be so wired that blades will be "dead" when switch is open.

When switches are used in rooms where combustible flyings would be likely to accumulate around them, they should be enclosed in dust-tight cabinets.

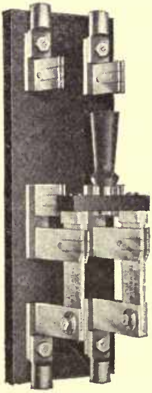
Up to 250 volts and thirty amperes, *approved indicating snap* switches are suggested in preference to knife switches on lighting circuits.

Single pole switches should never be used as service switches nor for the control of outdoor

signs or circuits located in damp places, nor placed in the neutral wire of a three-wire system, except in the two-wire branch or tap circuit supplying not more than 660 watts.

Three-way switches are considered as single pole switches.

Where flush switches or receptacles are used, whether with conduit systems or not, they should



An Approved Double Pole Knife Switch, Showing Terminals for Approved Enclosed Fuses. Always install so that the handle will be *up* when circuit is closed.

be enclosed in an *approved* box constructed of iron or steel, in addition to the porcelain enclosure of the switch or receptacle. Where in floor outlets attachment plugs are liable to mechanical injury, or the presence of moisture is probable, floor outlet boxes especially designed for this purpose should be used.

Where possible, at all switch or fixture outlets,

unless outlet boxes which will give proper support for fixtures are used, a seven-eighths inch block should be fastened between studs or floor timbers flush with the back of lathing to hold tubing, and to support switches or fixtures. When this cannot be done, wooden base blocks, not less than three-fourths inch in thickness, securely screwed to lathing, or approved fittings or plates designed for the service, should be provided for switches, and also for fixtures which are not attached to gas pipes or conduit.

Sub-bases of non-combustible, non-absorptive, insulating material, which will separate the wires at least one-half inch from the surface wired over, should be installed under all snap switches used in exposed knob and cleat work. Sub-bases should also be used in moulding work, but they may be made of hardwood or they may be omitted if the switch is approved for mounting directly on the moulding.

Flush Switches. Where gangs of flush switches are used, whether with conduit systems or not, the switches should be enclosed in boxes constructed of, or lined with, fire-resisting material.

Where two or more switches are placed under one plate, the box should have a separate compartment for each switch. No push buttons for bells, gas-lighting circuits, or the like, should be placed in the same wall plate with switches controlling electric light or power wiring.

Snap Switches like knife switches, should always be mounted on non-combustible, non-absorptive insulating bases, such as slate or porcelain, and

should have carrying capacity sufficient to prevent undue heating.

When used for service switches they should indicate at sight whether the current be "on" or "off." Indicating switches should be used for all work to prevent mistakes and possible accidents. The fact that lights do not burn or the motor does not run is not necessarily a sure sign that the current is off.

Every switch, like every other piece of electrical apparatus, should be plainly marked where it is always visible with the maker's name and the current and voltage for which it is designed.

On constant potential systems, these switches, like knife switches, should operate successfully at 50 per cent. overload in amperes with 25 per cent. excessive voltage under the most severe conditions they are likely to meet with in practice. They should have a firm contact, should make and break readily, and not stop when motion has once been imparted to the handle.

On constant current systems, they should close the main circuit and disconnect the branch wires when turned "off"; should be so constructed that they will be automatic in action, not stopping between points when started and should prevent an arc between the points under all circumstances.

LAMP DATA

The illumination given by one candle at a distance of one foot is called the "candle foot," and is taken as a unit of intensity. In general, intensity of illumination should nowhere be less than one candle-foot, and the demand for light at the

INCANDESCENT LAMP DATA

CARBON LAMPS

Volts	Watts	C. P.	W. P. C.	Amps.	Hot Res.
110	10	2.0	5.00	0.191	1210.00
"	20	4.8	4.15	0.182	605.00
"	30	9.3	3.23	0.273	403.00
"	50	16.8	2.97	0.455	242.00
"	60	20.2	2.97	0.546	201.80
220	30	5.1	5.90	0.1363	1613.3
"	35	8.0	4.40	0.159	1382.00
"	60	16.3	3.69	0.273	806.00

GEM LAMPS (METALLIC FILAMENT)

Volts	Watts	C. P.	W. P. C.	Amps.	Hot Res.
110	20	5.0	4.00	0.1818	605.0
"	30	10.0	3.00	0.273	403.3
"	40	15 6	2.56	0.364	302.0
"	50	20.0	2.50	0.455	242.0
"	60	24.0	2.50	0.546	201.5
"	80	32 5	2.46	1.727	151.4
"	100	40.7	2.46	1.909	121.0

MAZDA (VACUUM) LAMPS

Volts	Watts	C. P.	W. P. C.	Amps.	Hot Res.
110	10	7.7	1.30	0.0909	1210.0
"	15	13.0	1.15	0.1363	807.0
"	20	18.2	1.10	0 1818	605.0
"	25	23.8	1.05	0.227	484.0
"	40	38.8	1.03	0.364	302.5
"	60	60.0	1.00	0.546	201.7
"	100	105.0	.95	0.909	121.0
"	150	167.0	.90	1.363	80.7
"	250	278.0	.90	2.272	48.4
"	400	444.0	.90	3.640	30.2
"	500	556.0	.90	4.550	24.2

MAZDA (TYPE C) LAMPS (GAS FILLED) tungsten

Volts	Watts	C. P.	W. P. C.	Amps.	Hot Res.
110	200	250.0	0.80	1.82	60.5
"	300	385.0	0.78	2.73	40.3
"	400	533.0	0.75	3.64	30.3
"	500	714.0	0.70	4.55	24.2
"	750	1250.0	0.60	6.82	16.1
"	1000	1820.0	0.55	9.09	12.1
220	25	19.2	1 30	0.1136	1936.0
"	40	33.3	1.20	0.1818	1210.0
"	60	50.0	1.20	0.273	807.0
"	100	90.9	1.10	0.455	484.0
"	150	143.0	1.05	0.682	322.6
"	250	250.0	1.00	1.136	193.6
"	500	556.0	1.00	2.273	96.7

The tables below show the variation in the life and candle-power of incandescent lamps with various percentages of decrease and increase of rated voltage:

CARBON FILAMENT LAMP VARIATIONS.

% Volts	% C. P.	% Amperes	% Ohms	% Watts	% W. P. C.	% Life
Increase	Increase	Increase	Practically Constant	Increase	Decrease	Decrease
10	69.8	10.8		21.9	28.2	85.5
9	61.4	9.7		19.5	25.9	82.6
8	53 4	8.5		17 2	23.5	79.0
7	45.6	7.5		15.0	21.0	74.6
6	38.2	6.4		12.8	18.4	69.3
5	31.1	5.4		10.6	15.7	62.7
4	24.3	4.2		8.4	12.8	54.8
3	17.9	3.2		6.3	9.8	45.1
2	11.6	2.1		4.2	6.7	33.1
1	5.7	1.2		2.1	3.4	18.5
Normal	0	0		0	0	0
Decrease	Decrease	Decrease		Decrease	Increase	Increase
1	5.4	1.2		2.1	3.6	22.5
2	10.6	2.1		4.1	7.3	50.5
3	15.5	3.2		6.1	11.2	85.3
4	20 3	4.2		8.1	15.3	128 9
5	24.8	5.4		10.1	19.6	180.0
6	29.0	6.4		12.0	24.1	250.4
7	33.2	7.4		13.9	28.8	336.0
8	37.1	8.4		15 8	33.8	442.0
9	40.7	9.5		17.7	39.0	578.0
10	44.3	10.7		19.6	44.4	747.0

METAL FILAMENT LAMP VARIATIONS.

% Change in Voltage	% C. P. Mazda (Vacuum)	% Watts Mazda (Vacuum)	% C. P. Mazda (Type C.)	% Watts Mazda (Type C.)	% C. P. Gem	% Watts Gem
Increase	Increase	Increase	Increase	Increase	Increase	Increase
10	39.7	16.3	36.3	15.9	58.0	18.4
9	35.3	14.6	32.3	14.3	51.3	16.5
8	31.0	12.9	28.4	12.7	44.7	14.6
7	26.8	11.3	24.6	11.2	38.4	12.7
6	22.7	9.6	20.8	9.5	32.3	10.8
5	18.7	8.0	17.2	7.9	26.4	9.0
4	14.8	6.4	13.6	6.2	20.7	7.2
3	10.9	4.8	10.1	4.7	15.2	5.4
2	7.2	3.2	6.6	3.1	10.0	3.6
1	3.6	1.6	3.3	1.6	4.9	1.8
Normal	0	0	0	0	0	0
Decrease	Decrease	Decrease	Decrease	Decrease	Decrease	Decrease
1	3.5	1.6	3.3	1.6	4.7	1.8
2	7.0	3.3	6.4	3.0	9.3	3.6
3	10.3	4.6	9.5	4.6	13.6	5.3
4	13.4	6.2	12.5	6.0	17.8	7 0
5	16.4	7.8	15.5	6.5	21.8	8.7
6	19.6	9.4	18.2	9.0	25.7	10.4
7	22.5	11.0	21.0	10.4	29.4	12.1
8	25.4	12.4	23.8	12.0	33.0	13.8
9	28.2	14.0	26.4	13.3	36.4	15.5
10	30.9	15.3	29.0	15.0	39.7	17.1

COOPER HEWITT LAMP UNITS—DIRECT CURRENT

Type	Watts	Length of tubes, ins.	Candle power	Watts per candle.
H	192	21″	300	.64
Double H	385	2-21″ ea.	600	.64
K	385	45″	700	.55
P	385	50″	800	.48

ALTERNATING CURRENT (60-cycle, 95-125 volts)

F	400	50″	800	.50

Power Factor 70%.

COOPER HEWITT QUARTZ LAMP—DIRECT CURRENT

Y for 110 volts	418	1¼″	1000	.40
Z " 220 "	725	4 ″	2400	.30

present time quite frequently raises the brilliancy to double this amount. The intensity of light varies inversely with the square of the distance. A 16-candle-power lamp gives a candle-foot of light as a distance of four feet. A candle-foot of light is a good intensity for reading purposes.

Assuming the 16-candle-power lamp as the standard, it is generally found that two 16-candle-power lamps per 100 square feet of floor space gives good illumination, three very bright, and four brilliant. These general figures will be modified by the height of ceiling, color of walls and ceiling, and other local conditions. The lighting effect is reduced, of course, by an increased height of ceiling. A room with dark walls requires nearly three times as many lights for the same illumination as a room with walls painted white. With the amount of intense light available in arc and incandescent lighting, there is danger of exceeding "the limits of effective illum-

ination and producing a glaring intensity," which should be avoided as carefully as too little intensity of illumination.

Distribution considers the arrangement of the various sources of light and the determination of their candle-power. The object should be to "secure a uniform brilliancy on a certain plane, or within a given space. A room uniformly lighted, even though comparatively dim, gives an effect of much better illumination than where there is great brilliancy at some points and comparative darkness at others. The darker parts, even though actually light enough, appear dark by contrast, while the lighter parts are dazzling. For this reason naked lights of any kind are to be avoided, since they must appear as dazzling points, in contrast with the general illumination."

The arrangement of the lamps is dependent very largely upon existing conditions. In factories and shops, lamps should be placed over each machine or bench so as to give the necessary light for each workman. In the lighting of halls, public buildings and large rooms, excellent effects are obtained by dividing the ceilings into squares and placing a lamp in the center of each square. The size of square depends on the height of ceiling and the intensity of illumination desired. Another excellent method consists in placing the lamps in a border along the walls near the ceiling.

For the illumination of show windows and display effects, care must be taken to illuminate by reflected light. The lamps should be so placed as

to throw their rays upon the display without casting any direct rays on the observer.

The relative value of high candle-power lamps in place of an equivalent number of 16-candle-power lamps is worthy of notice. Large lamps can be efficiently used for lighting large areas, but in general, a given area will be much less effectively lighted by high candle-power lamps than by an equivalent number of 16-candle-power lamps. For example, sixteen 64-candle-power lamps distributed over a large area will not give as good general illumination as sixty-four 16-candle-power lamps distributed over the same area. High candle-power lamps are chiefly useful when a brilliant light is needed at one point, or where space is limited and an increase in illuminating effect is desired.

The relative value of the arc and incandescent systems of lighting is frequently difficult to determine. Incandescent lamps have the advantage that they can be distributed so as to avoid the shadows necessarily cast by one single source of light. Arc lamps used indoors with ground or opal globes cutting off half the light, have an efficiency not greater than two or three times that of an incandescent lamp. Nine 50-watt, 16-candle-power lamps consume the same power as one full 450-watt arc lamp. It has been found that unless an area is so large as to require 200 or 300 incandescent lights distributed over it, arc lamps requiring total power will not light the area with as uniform brilliancy.

Cut-Outs, other than rosettes and attachment plugs, are of two classes: The link-fuse cut-out

and the enclosed-fuse cut-out. In both cases they should be supported on bases of non-combustible, non-absorptive insulation material.

All cut-outs should be of the enclosed type, when not arranged in *approved* cabinets, so as to obviate any danger of the melted fuse metal coming in contact with any substance which might be ignited thereby.

Cut-outs must operate successfully on short circuits, under the most severe conditions with which they are liable to meet in practice, at 25 per cent. above their rated voltage, and for link-fuse cut-outs with fuses rated at 50 per cent. above the current for which the cut-out is designed, and for enclosed-fuse cut-outs with the largest fuses for which the cut-out is designed.

With link-fuse cut-outs there is always the possibility of a larger fuse being put into the cut-out than it was designed for, which is not true of enclosed-fuse cut-outs.

The most severe service which can be required of a cut-out in practice is to open a "dead short-circuit," with only one fuse blowing, and it is with these conditions that all tests should be made.

Cut-outs should be marked where it will be plainly visible when installed with the name of the maker, and current and voltage for which the device is designed.

LINK-FUSE CUT-OUTS.

Should be mounted on bases made of strong,

non-combustible, non-absorptive, insulating material. The design of the base should be such that, considering the material used, the base will withstand the most severe conditions liable to be met in practice. Bases with an area of over twenty-five square inches should have at least four supporting screws. Holes for supporting screws should be kept outside of the area included by the outside edges of the fuse-block terminals, and should be so located or countersunk that there will be at least one-half of an inch space, measured over the surface, between the head of the screw or washer and the nearest live metal part.

Nuts or screw heads on the under side of the base should be countersunk not less than one-eighth inch, and covered with a waterproof compound.

All fuse-block terminals should have ample metal for stiffness and to prevent rise in temperature of any part of over 50 degrees Fahr. (28 degrees Cen.) at full load. Terminals, as far as practicable, should be made of compact form instead of being rolled out in thin strips; and sharp edges or thin projecting pieces, as on wing thumb nuts and the like, should be avoided. Thin metal, sharp edges and projecting pieces are much more likely to cause an arc to start than a more solid mass of metal.

Clamps for connecting the wires to the fuse-block terminals should be of solid, rugged construction, so as to insure a thoroughly good connection and to withstand considerable hard usage. For fuses rated at over 30 amperes, lugs firmly screwed or bolted to the terminals and into which the conducting wires are soldered should be used.

Spacings should be at least as great as those given in the following table:

OPEN LINK FUSES 125 VOLTS OR LESS.	Separation ofnearest metal parts of opposite polarity.	Minimum break distance.
10 amperes or less	¾ inch	¾ inch.
11—100 amperes	1 "	¾ "
101—300 "	1 "	1 "
UP TO 250 VOLTS.		
10 amperes or less	1½ "	1¼ "
11—100 amperes	1¾ "	1¼ "
101—300 "	2 "	1½ "

A space should be maintained between fuse terminals of the *same polarity* of at least one-half inch for voltages up to 125, and of at least three-quarter inch for voltages from 126 to 250. This is the minimum distance allowable, and greater separation should be provided when practicable.

For 250 volt boards or blocks with the ordinary front-connected terminals, except where these have a mass of compact form, equivalent to the back-connected terminals usually found in switchboard work, a substantial barrier is insulating material, not less than one-eighth of an inch in thickness, should be placed in the "break" gap—this barrier to extend out from the base at least one-eighth of an inch farther than any bare live part of the fuse-block terminal, including binding screws, nuts and the like.

For three-wire systems cut-outs should have the break-distance required for circuits of the potential of the outside wires.

ENCLOSED-FUSE CUT-OUTS—PLUG AND CARTRIDGE TYPE.

The bases should be made of non-combustible,

non-absorptive, insulating material. Blocks with an area of over twenty-five square inches should have at least four supporting screws. Holes for supporting screws must be so located or countersunk that there will be at least one-half of an inch space, measured over the surface, between the screw-head or washer and the nearest live metal part, and in all cases when between parts of opposite polarity should be countersunk.

Nuts or screw-heads on the under side of the base should be countersunk at least one-eighth of an inch and covered with a waterproof compound.

Except for sealable service and meter cut-outs, terminals should be of either the Edison plug, spring clip or knife-blade type, of *approved* design, to take the corresponding standard enclosed fuses. They should be secured to the base by two screws or the equivalent, so as to prevent them from turning, and must be so made as to secure a thoroughly good contact with the fuse. End stops should be provided to insure the proper location of the cartridge fuse in the cut-out.

Clamps for connecting wires to the terminals should be of a design which will insure a thoroughly good connection and should be sufficiently strong and heavy to withstand considerable hard usage. For fuses rated to carry over thirty amperes, lugs firmly screwed or bolted to the terminals and into which the connecting wires shall be soldered should be used.

They should be classified as regards both current and voltage.

ENCLOSED FUSES (CARTRIDGE TYPE).

Fuses of this type for light, power and heating circuits should have their fusible strips, or wire, permanently attached to their terminals within the cartridge so as to obtain a thoroughly good connection and make it impossible to replace, by the user, when melted by an overload or short circuit.

No enclosed fuses should ever be used which do not bear the name, or trade-mark of the maker, and the words "National Electrical Code Standard," or its abbreviation, "N. E. Code Std.," or "N. E. C. S."

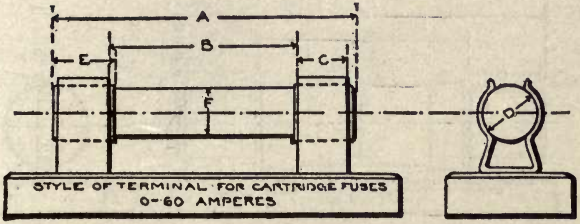
No enclosed fuses should ever be refilled by the user but should be returned to their makers, who will refill them at a nominal cost.

There are no "Renewable" or "Refillable" enclosed or cartridge fuses, so-called, approved by the National Board of Fire Underwriters, or appear in the list of Electrical Fittings published by the National Board of Fire Underwriters.

Following is the list of makers of approved enclosed or cartridge fuses: Bryant Electric Co.. "Bryant"; Chase-Shawmut Co., "Shawmut" (Condit Electrical Mfg. Co., sole agents); Chicago Fuse Mfg. Co., "Union"; Detroit Fuse & Mfg.. Co., "Arkless"; D. & W. Fuse Co., "D. & W."; General Electric Co., "G. E."; Johns-Pratt Co., "Noark" (H. W. Johns-Manville Co., sole agents); Westinghouse Elec. & Mfg. Co., "Westinghouse."

For dimensions of National Electrical Code Standard fuses see two following pages.

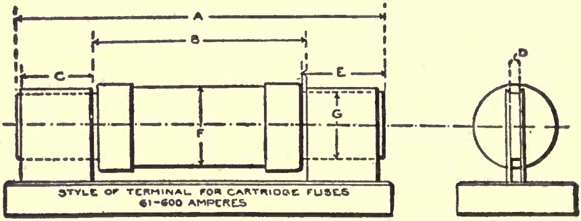
Table of Dimensions of the Standard Cartridge



Form 1. CARTRIDGE FUSE—Ferrule Contact.

Voltage.	Rated Capacity. Amperes.		A Length over Terminals. Inches.	B Distance between Contact Clips. Inches.	C Width of Contact Clips. Inches.
0-250	0-30	Form 1	2	1	$\frac{1}{2}$
	31-60	Form 1	3	$1\frac{3}{4}$	$\frac{5}{8}$
	61-100	Form 2	$5\frac{7}{8}$	4	$\frac{7}{8}$
	101-200	Form 2	$7\frac{1}{8}$	$4\frac{1}{2}$	$1\frac{1}{4}$
	201-400	Form 2	$8\frac{5}{8}$	5	$1\frac{3}{4}$
	401-600	Form 2	$10\frac{3}{8}$	6	$2\frac{1}{8}$
251-600	0-30	Form 1	5	4	$\frac{1}{2}$
	31-60	Form 1	$5\frac{1}{2}$	$4\frac{1}{2}$	$\frac{5}{8}$
	61-100	Form 2	$7\frac{7}{8}$	6	$\frac{7}{8}$
	101-200	Form 2	$9\frac{5}{8}$	7	$1\frac{1}{4}$
	201-400	Form 2	$11\frac{5}{8}$	8	$1\frac{3}{4}$

National Electrical Code
Enclosed Fuse.

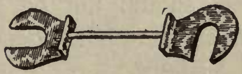


Form 2. CARTRIDGE FUSE—Knife Blade Contact.

D	E	F	G		
Dia. of Ferrules or Thickness of Terminal Blades. Inches.	Min. Length of Ferrules or of Terminal Blades Outside of Tube. Inches.	Dia. of Tube. Inches.	Width of Terminal Blades. Inches.		Rated Capacity. Amperes
$\frac{9}{16}$ $\frac{13}{16}$	$\frac{1}{2}$ $\frac{5}{8}$	$\frac{1}{2}$ $\frac{3}{4}$		Form 1	0-30 31-60
$\frac{1}{8}$ $\frac{13}{16}$ $\frac{1}{4}$ $\frac{1}{4}$	1 $1\frac{3}{8}$ $1\frac{7}{8}$ $2\frac{1}{4}$	1 $1\frac{1}{2}$ 2 $2\frac{1}{2}$	$\frac{3}{4}$ $1\frac{1}{8}$ $1\frac{5}{8}$ 2	Form 2	61-100 101-200 201-400 401-600
$\frac{13}{16}$ $1\frac{1}{16}$	$\frac{1}{2}$ $\frac{5}{8}$	$\frac{3}{4}$ 1		Form 1	0-30 31-60
$\frac{1}{8}$ $\frac{3}{16}$ $\frac{1}{4}$	1 $1\frac{3}{8}$ $1\frac{7}{8}$	$1\frac{1}{4}$ $1\frac{3}{4}$ $2\frac{1}{2}$	$\frac{3}{4}$ $1\frac{1}{8}$ $1\frac{5}{8}$	Form 2	61-100 101-200 201-400

CURRENT REQUIRED TO FUSE WIRES OF COPPER, GERMAN SILVER AND IRON.

B. & S. Gauge.	Copper, Amperes.	German Silver, Amperes.	Iron, Amperes.
10	333.	169.	101.
11	284.	146.	86.
12	235.	120.7	71.2
13	200.	102.6	63.
14	166.	85.2	50.2
15	139.	71.2	42.1
16	117.	60.	35.5
17	99.	50.4	32.6
18	82.8	42.5	25.1
19	66.7	34.2	20.2
20	58.3	29.9	17.7
21	49.3	25.3	14.9
22	41.2	21.1	12.5
23	34.5	17.7	10.9
24	28.9	14.8	8.76
25	24.6	12.6	7.46
26	20.6	10.6	6.22
27	17.7	9.1	5.36
28	14.7	7.5	4.45
29	12.5	6.41	3.79
30	10.25	5.26	3.11
31	8.75	4.49	2.65
32	7.26	3.73	2.2
33	6.19	3.18	1.88
34	5.12	2.64	1.55
35	4.37	2.24	1.33
36	3.62	1.86	1.09
37	3.08	1.58	.93
38	2.55	1.31	.77
39	2.20	1.13	.67
40	1.86	.95	.56



The above cut illustrates the manner in which harder metal tips should be attached to fuse wire.

LINK FUSES.

Should have contact surfaces or tips of harder metal, having perfect electrical connections with the fusible part of the strip.

The use of the hard metal tip is to afford a strong mechanical bearing for the screws, clamps, or other devices provided for holding the fuse.

They should be stamped with about 80 per cent. of the maximum current which they can carry indefinitely, thus allowing about 25 per cent. overload before the fuse melts.

With naked open fuses, of ordinary shapes and with not over 500 amperes capacity, the *minimum* current which will melt them in about five minutes may be safely taken as the melting point, as the fuse practically reaches its maximum temperature in this time. With larger fuses a longer time is necessary.

Fuse terminals should be stamped with the maker's name or initials, or with some known trademark.

Cabinets. Should in all cases be made amply strong and rigid to keep their shape, permitting their doors to close tightly, and making it possible to install the wiring and conduit properly. Cabinets may be constructed of cast or sheet metal, wood or approved composition. Wood or composition cabinets should not be used when connected with metal conduit, metal moulding, or armored cable systems.

All metal cabinets should be thoroughly painted or treated to prevent rust or corosion.

Wooden Cabinets. Wood should be well seasoned and at least three-fourths inch thick, and be thoroughly filled and painted, and should be lined with a non-combustible material.

In all cabinets, linings of slate, marble or approved composition should be at least one-fourth inch thick and firmly secured in place; when metal is used for the lining it should be at least No. 16 U. S. gage in thickness. For lining wooden cabinets one-eighth inch rigid asbestos board may be used when firmly secured in place by screws or tacks.

Metal Cabinets. If cast metal is used a thickness of at least one-eighth inch should be provided. Sheet metal should not be less than .0625 inch thick (No. 16 U. S. gage). In steel cabinets having an area of more than 360 square inches for any surface, or having a single dimension greater than 2 feet, sheet metal should be used at least No. 14 U. S. gage in thickness; in those having an area of more than 1,200 square inches for any surface, or having a single dimension greater than 4½ feet, the sheet metal should be at least No. 12 U. S. gage in thickness.

Doors should shut closely at all edges against a rabbet formed as a part of the door or trim or have turned flanges at all edges. Hinges should be of strong and durable design. A substantial latch or catch should be provided so as to keep the door closed, and a lock may be used in addition to the catch if desired.

When doors have glass panels the glass should

be at least one-eighth inch thick (commercial thickness), and should not have a greater area than 450 square inches unless plate glass at least one-fourth inch in thickness is used.

Every cabinet should be marked with manufacturer's name, where the name can be plainly seen when the cabinet is installed.

Arc Lamps should be carefully isolated from inflammable material, should be provided at all times with a glass globe surrounding the arc and securely fastened upon a closed base. No broken or cracked globes should be used, as they are designed to prevent hot bits of carbon or even an entire carbon from falling to the floor should it fall from the carbon holder. All globes for inside work should be covered with a wire netting having a mesh not exceeding one and one-quarter inches, to retain the pieces of the globe in position should the latter become broken from any cause. A globe thus broken should be replaced at once. When arc lamps are used in rooms containing readily inflammable material they should be provided with approved *spark arresters,* which should be made to fit so closely to the upper orifice of the globe that it will be impossible for any sparks thrown off by the carbons to escape. It is safe to use plain carbon and not copper-plated ones in such rooms, or better still, an enclosed arc lamp, one having its carbons enclosed in a practically tight glass globe which is inside the outer globe. Where hanger-boards are not used arc lamps should be

hung from insulating supports other than their conductors.

All arc lamps should be provided with reliable tops to prevent carbons from falling out in case the lamps become loose, and all exposed parts should be carefully insulated from the circuit. Each lamp for constant current systems, should be provided with an approved hand switch, and also an automatic switch that will shunt the current around the carbons, so that the lamp will thus cut itself out of circuit should the carbons fail to feed properly. If the hand switch is placed anywhere except on the lamp itself it should comply in every respect with the requirements for switches on hanger-boards as described under the latter heading.

Arc Light Wiring (High Potential). All wiring for high potential arc lighting circuits should be done with "Rubber Covered" wire. The wires should be arranged to enter and leave the building through an approved doubled contact service switch which should close the main circuit and disconnect the wires in the building when turned "off" and be so constructed that they will be automatic in their action, not stopping between points when started and to prevent arcing between points under any circumstances, and should indicate plainly whether the current is "on" or "off." Never use snap switches for arc lighting circuits. All arc light wiring of this class should be in plain sight and never enclosed, except when required, and should be supported on porcelain or glass insulators which separate the wires at least one inch from the sur-

face wired over. The wires should be kept rigidly at least eight inches apart, except of course within the lamp, hanger-board or cut-out box or switch. On side walls the wiring should be protected from mechanical injury by a substantial boxing, retaining an air space of one inch around the conductors, closed at the top (the wires passing through bushed holes), and extending not less than seven feet from the floor. When crossing floor timbers in cellars or in rooms, where they might be exposed to injury, wires should be attached by their insulating supports to the under side of a wooden strip not less than one-half an inch in thickness.

Arc Lamp on Low Potential Circuits should have a cut-out for each lamp or series of lamps. The branch conductors for such lamps should have a carrying capacity about 50 per cent. in excess of the normal current required by the lamp or lamps to provide for the extra current required when the lamps are started or should a carbon become stuck without over-fusing the wires. If any resistance coils are necessary for adjustment or regulation, they should be enclosed in non-combustible material and be treated as sources of heat; it is preferable that such resistance coils be placed within the metal framework of the lamp itself. Incandescent lamps should never be used for resistance devices. These lamps should be provided with globes and spark arresters, as in the case of arc lamps on high-potential series circuits, except when the enclosed arc lamps are used.

Economy Coils or compensator coils for arc lamps should be mounted on glass or porcelain, al-

lowing an air space of at least one inch between frame and support, and in general to be treated like sources of heat.

Hanger Boards should be so constructed that all wires and current-carrying devices thereon will be exposed to view and thoroughly insulated on non-combustible, non-absorptive insulating substance, such as porcelain.

All switches attached to the hanger-board should be so constructed that they will be automatic in their action, cutting off both poles to the lamp, not stopping between points under all circumstances.

Electric Heaters should always be treated as sources of heat and kept away from inflammable materials. Each heater should have a cut-out and *indicating* switch and all attachments from the feed wires to the heater should be kept in plain sight, easily accessible and protected from interference. Each heater should have a name plate giving the maker's name, and the normal capacity in volts and amperes.

Car House Wiring. All trolley wires in car houses should be securely supported on insulating hangers. The trolley hangers should be placed close enough together to prevent the trolley wire, should it break from any cause, from coming in contact with the floor or rails within the building, or even in contact with the ironwork on the trucks or wheels of the car, as it hangs down. A broken trolley wire in this way would produce dangerous arcing and probably start a fire.

All the wires in the car house should be con-

trolled by a cut-out switch, located on a pole at least 100 feet from the building, so that in case of fire or for other reasons all wires could be controlled from that point. The current should always be cut out of the car house when the same is not in use or the road not in operation. All lamps and stationary motors used in car houses should be installed in such a way that one main switch can control the whole of each installation independently of the main feeder switch. No portable incandescent lamps or twin wire should be used, except in the car pits, where they may be used when connections are made by two approved rubber-covered flexible wires, properly protected against mechanical injury, and all such pit wiring be controlled by a separate switch for each pit placed outside of the pit. All wiring for lights or motors within the car house should be with approved rubber-covered wire and supported on single porcelain or glass insulators which separate the wires from surface wired over by one inch. No system of feeder distribution should center in the car house.

All rails within the building should be bonded at each joint with annealed copper wire, not smaller than No. 00 B. & S. gage.

When cars are run in the house they should not be left with their trolleys in contact with the trolley wire, as frequent fires have been caused by the motorman or conductor forgetting to turn off the car heater current or other car wiring, and during the course of the night, or other times, "burn-outs"

have occurred, followed by fire, and, as once happened in the course of the writer's experience, the total loss of a large car house and a number of valuable cars and other stock. Current from trolley systems, having a grounded return wire, should never be used for any purpose in or on buildings other than car houses or their power stations.

Approved Apparatus and Supplies. Every article or fitting intended for use in electrical wiring or construction or in connection therewith should, before being manufactured or placed upon the market, be submitted to the Underwriters' Laboratories, 207 East Ohio street, Chicago, for examination and report. Branch offices are located in thirty-two other cities of the United States and Canada. The New York office, at 135 William street, is equipped for the conduct of examinations and tests of all electrical devices under the same conditions as those afforded at the principal office and testing station in Chicago.

The amounts of the fees are in proportion to the nature and extent of the work required in examinations and tests. When such article or device is approved and found safe and suitable for the use intended, it is placed on the List of Electrical Fittings issued semi-annually by the National Board of Fire Underwriters, for use in accordance with the rules and requirements of the National Electrical Code as given in the foregoing pages of this book.

When buying electrical supplies of any description make sure that they have been approved, or that their use will be permitted. If there is any

question about it, make your supply dealer, or the manufacturer give you a guarantee that they will be approved by the Fire Underwriters' Inspector if installed in accordance with the rules and requirements of the National Electrical Code.

Electrical Inspection. The principal points regarding the safe installation of dynamos, motors, outside and inside wiring, as required by the insurance underwriters, have been briefly set forth in this little book, which has been compiled simply for reference and not as a teacher—a book designed to settle most of the doubtful questions which might arise on the mind of the engineer or contractor as to just what will be considered safe by insurance inspectors. There will probably arise questions which cannot be settled by reference to the suggestions herein contained, and, therefore, a great deal has to be left to the judgment of the constructing engineer and inspector. In every such case the Inspection Department having jurisdiction should be consulted with perfect assurance that nothing unreasonable will ever be demanded in the way of special construction.

Every piece of wiring or electrical construction work, whether open or concealed, should be inspected, and *notice,* therefore, *should always be sent by the contractor or engineer to the board having jurisdiction immediately upon completion of any work.* Negligence in this matter has frequently caused floors to be torn up when doubtful work has been suspected, and at the cost of the parties who installed the wiring.

WIRE TABLE, STANDARD ANNEALED COPPER.

Gage No. B. & S.	Diameter in Mils at 20° C	Cross Section Circular Mils	Ohms per 1000 Feet * 0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	211 600.	0.045 16	0.049 01	0.054 79
000	409.6	167 800.	.056 95	.061 80	.069 09
00	364.8	133 100.	.071 81	.077 93	.087 12
0	324.9	105 500.	.09055	.09827	.1099
1	289.3	83 690.	.1142	.1239	.1385
2	257.6	66 370.	.1440	.1563	.1747
3	229.4	52 640.	.1816	.1970	.2203
4	204.3	41 740.	.2289	.2485	.2778
5	181.9	33 100.	.2887	.3133	.3502
6	162.0	26 250.	.3640	.3951	.4416
7	144.3	20 820.	.4590	.4982	.5569
8	128.5	16 510.	.5788	.6282	.7023
9	114.4	13 090.	.7299	.7921	.8855
10	101.9	10 380.	.9203	.9989	1.117
11	90.74	8234.	1.161	1.260	1.408
12	80.81	6530.	1.463	1.588	1.775
13	71.96	5178.	1.845	2.003	2.239
14	64.08	4107.	2.327	2.525	2.823
15	57.07	3257.	2.934	3.184	3.560
16	50.82	2583.	3.700	4.016	4.489
17	45.26	2048.	4.666	5.064	5.660
18	40.30	1624.	5.883	6.385	7.138
19	35.89	1288.	7.418	8.051	9.001
20	31.96	1022.	9.355	10.15	11.35
21	28.46	810.1	11.80	12.80	14.31
22	25.35	642.4	14.87	16.14	18.05
23	22.57	509.5	18.76	20.36	22.76
24	20.10	404.0	23.65	25.67	28.70
25	17.90	320.4	29.82	32.37	36.18
26	15.94	254.1	37.61	40.81	45.63
27	14.20	201.5	47.42	51.47	57.53
28	12.64	159.8	59.80	64.90	72.55
29	11.26	126.7	75.40	81.83	91.48
30	10.03	100.5	95.08	103.2	115.4
31	8.928	79.70	119.9	130.1	145.5
32	7.950	63.21	151.2	164.1	183.4
33	7.080	50.13	190.6	206.9	231.3
34	6.305	39.57	240.4	260.9	291.7
35	5.615	31.52	303.1	329.0	367.8

* Resistance at the stated temperatures of a wire whose length is 1000 feet at 20° C. (Bureau of Standards)

WIRE TABLE, STANDARD ANNEALED COPPER.—CONTINUED.

Gage No. B. & S.	Diameter in Mils at 20° C	Pounds per 1000 Feet	Feet per Ohm * 0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
000	460.0	640.5	22 140.	20 400.	18 250.
000	409.6	507.9	17 560.	16 180	14 470.
00	364.8	402.8	13 930.	12 830.	11 480.
0	324.9	319.5	11 040.	10 180	9103.
1	289.3	253.3	8758.	8070.	7219.
2	257.6	200.9	6946.	6400.	5725.
3	229.4	159.3	5508.	5075.	4540.
4	204.3	126.4	4368.	4025.	3600.
5	181.9	100.2	3464.	3192.	2855.
6	162.0	79.46	2747.	2531.	2264.
7	144.3	63.02	2179.	2007.	1796.
8	128.5	49.98	1728.	1592.	1424.
9	114.4	39.63	1370.	1262.	1129.
10	101.9	31.43	1087.	1001.	895.6
11	90.74	24.92	861.7	794.0	710.2
12	80.81	19.77	683.3	629.6	563.2
13	71.96	15.68	541.9	499.3	446.7
14	64.08	12.43	429.8	396.0	354.2
15	57.07	9.858	340.8	314.0	280.9
16	50.82	7.818	270.3	249.0	222.8
17	45.26	6.200	214.3	197.5	176.7
18	40.30	4.917	170.0	156.6	140.1
19	35.89	3.899	134.8	124.2	111.1
20	31.96	3.092	106.9	98.50	88.11
21	28.46	2.452	84.78	78.11	69.87
22	25.35	1.945	67.23	61.95	55.41
23	22.57	1.542	53.32	49.13	43.94
24	20.10	1.223	42.28	38.96	34.85
25	17.90	0.9699	33.53	30.90	27.64
26	15.94	.7692	26.59	24.50	21.92
27	14.20	.6100	21.09	19.43	17.38
28	12.64	.4837	16.72	15.41	13.78
29	11.26	.3836	13.26	12.22	10.93
30	10.03	.3042	10.52	9.691	8.669
31	8.928	.2413	8.341	7.685	6.875
32	7.950	.1913	6.614	6.095	5.452
33	7.080	.1517	5.245	4.833	4.323
34	6.305	.1203	4.160	3.833	3.429
35	5.615	.095 42	3.299	3.040	2.719

* Length at 20° C of a wire whose resistance is 1 ohm at the stated temperatures. (Bureau of Standards).

WIRE TABLE, STANDARD ANNEALED COPPER. —CONTINUED.

Gage No. B. & S.	Diameter in Mils at 20° C	Ohms per Pound 0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	0.000 070 51	0.000 076 52	0.000 085 54
000	409.6	.000 1121	.000 1217	.000 1360
00	364.8	.000 1783	.000 1935	.000 2163
0	324.9	.000 2835	.000 3076	.000 3439
1	289.3	.000 4507	.000 4891	.000 5468
2	257.6	.000 7166	.000 7778	.000 8695
3	229.4	.001 140	.001 237	.001 383
4	204.3	.001 812	.001 966	.002 198
5	181.9	.002 881	.003 127	.003 495
6	162.0	.004 581	.004 972	.005 558
7	144.3	.007 284	.007 905	.008 838
8	128.5	.011 58	.012 57	.014 05
9	114.4	.018 42	.019 99	.022 34
10	101.9	.029 28	.031 78	.035 53
11	90.74	.046 56	.050 53	.056 49
12	80.81	.074 04	.080 35	.089 83
13	71.96	.1177	.1278	.1428
14	64.08	.1872	.2032	.2271
15	57.07	.2976	.3230	.3611
16	50.82	.4733	.5136	.5742
17	45.26	.7525	.8167	.9130
18	40.30	1.197	1.299	1.452
19	35.89	1.903	2.065	2.308
20	31.96	3.025	3.283	3.670
21	28.46	4.810	5.221	5.836
22	25.35	7.649	8.301	9.280
23	22.57	12.16	13.20	14.76
24	20.10	19.34	20.99	23.46
25	17.90	30.75	33.37	37.31
26	15.94	48.89	53.06	59.32
27	14.20	77.74	84.37	94.32
28	12.64	123.6	134.2	150.0
29	11.26	196.6	213.3	238.5
30	10.03	312.5	339.2	379.2
31	8.928	497.0	539.3	602.9
32	7.950	790.2	857.6	958.7
33	7.080	1256.	1364.	1524.
34	6.305	1998.	2168.	2424.
35	5.615	3177.	3448.	3854.

(Bureau of Standards)

WIRE TABLE, STANDARD ANNEALED COPPER—CONTINUED

Gage No. B. & S.	Diameter in Mils at 20° C	Pounds per Ohm		
		0° C (=32° F)	20° C (=68° F)	50° C (=122° F)
0000	460.0	14 180.	13 070.	11 690.
000	409.6	8920.	8219.	7352.
00	364.8	5610.	5169.	4624.
0	324.9	3528.	3251.	2908.
1	289.3	2219.	2044.	1829.
2	257.6	1395.	1286.	1150.
3	229.4	877.6	808.6	723.3
4	204.3	551.9	508.5	454.9
5	181.9	347.1	319.8	286.1
6	162.0	218.3	201.1	179.9
7	144.3	137.3	126.5	113.2
8	128.5	86.34	79.55	71.16
9	114.4	54.30	50.03	44.75
10	101.9	34.15	31.47	28.15
11	90.74	21.48	19.79	17.70
12	80.81	13.51	12.45	11.13
13	71.96	8.495	7.827	7.001
14	64.08	5.342	4.922	4.403
15	57.07	3.360	3.096	2.769
16	50.82	2.113	1.947	1.742
17	45.26	1.329	1.224	1.095
18	40.30	0.8357	0.7700	0.6888
19	35.89	.5256	.4843	.4332
20	31.96	.3306	.3046	.2725
21	28.46	.2079	.1915	.1713
22	25.35	.1307	.1205	.1078
23	22.57	.082 22	.075 76	.067 77
24	20.10	.051 71	.047 65	.042 62
25	17.90	.032 52	.029 97	.026 80
26	15.94	.020 45	.018 85	.016 86
27	14.20	.012 86	011 85	.010 60
28	12.64	.008 090	.007 454	.006 668
29	11.26	.005 088	.004 688	.004 193
30	10.03	.003 200	.002 948	.002 637
31	8.928	.002 012	.001 854	.001 659
32	7.950	.001 266	.001 166	.001 043
33	7.080	.000 7959	.000 7333	.000 6560
34	6.305	.000 5005	.000 4612	.000 4126
35	5.615	.000 3148	.000 290[illegible]	.000 2595

(Bureau of Standards)

HOUSE WIRING.

Special Suggestions and Recommendations to the House Owner, Architect, Contractor and Wireman, with the co-operation of the National Electric Light Association Committee on Wiring Existing Buildings and the Society for Electrical Development, in Accordance with the Rules and Requirements of the National Board of Fire Underwriters.

Obtaining Service.

In every case where the electric wires have not been introduced into a house, it is necessary to consult the central station as to the terms on which service can be obtained.

When the wires are not even on the street it will always be necessary for the central station to make an extension, involving additional mains, as the electric wires in the street are called, and usually additional poles for overhead wires, or digging for conduits for underground wires.

It may be noted here that the current for trolley service is not suitable for house lighting, nor is such service allowed by the insurance interests in any part of the country.

No one but the central station representative can determine the cost of making an extension, and all that can be said in this general treatise is that sometimes the central station will extend its wires without any guarantee, on the chance that the new business will be profitable. In other cases the prospective customer is asked to guarantee a definite income for a term of years, or to make a deposit towards the cost of the extension, to be returned

out of the income; or in extreme cases, even to pay the whole cost. Each case has to be considered separately; but in this country a somewhat general rule is to make extensions when the annual income, either estimated or guaranteed, is equal to about half the cost of the additional investment, or cost of the extension beyond the point to which the lines have been already built.

In regard to whether the service is overhead or underground, this usually depends on the character of the neighborhood, dense city districts being supplied underground, and suburban or country districts overhead.

If in a district where the wires are underground, the central station extends the mains along the street, and usually branches from the mains to the lot line without further charge for the branch. Sometimes the street construction is such that the house service comes from the wire directly opposite. In other cases there are manholes in the street at convenient intervals, and the wires run directly from such manhole to the house.

Sometimes a charge is made by the central station for the whole of the branch to the house, but more usually there is no charge for the work in the public streets, and often the wire is carried free to the house wall, especially if the house is close to the street. If, however, there is a wide lawn a charge is often made, running from 75 cents to $1.50 per foot, according to circumstances. In the case of new houses it is often convenient to use the same trench or conduits for the telephone wires also, and sometimes even for the water pipe.

As the central station will always either do this underground work itself or furnish definite and complete specifications, no further reference need be made to it here.

In the case of overhead wires questions about the extension of the central station wires in the street come up. The householder should appreciate that overhead wires are installed only in districts where the cost of underground is prohibitive, so that if the central station cannot obtain the right to set the necessary poles in such districts it may not be able to extend the wires at all.

When the necessary poles are near enough the central station will usually run the wires from the pole to the house without further charge.

In other cases, as when the house sets far back, or when for some special reason the wires have to enter the house in the rear, it may be necessary to set poles on the private property, for which work the central station will frequently make a charge, which should run from say $10 to $50, about $25 for each pole together with the wire, cross arms, insulators, etc.

Of course, when the customer is willing to pay for it, the central station will run its wires down the pole into the ground and supply the house by an underground service, even in overhead districts.

The Code rules governing outside work for both overhead and underground are as follows:;

a. Line wires must have an approved weather-proof or rubber insulating covering (see p. 67). That portion of the service wires between the main cut-out and switch and the first support from the

cut-out or switch on outside of the building must have an approved rubber insulating covering, but from the above-mentioned support to the line, except when run in conduit, may have an approved weatherproof insulating covering if kept free from awnings, swinging signs, shutters, etc.

b. Must be so placed that moisture cannot form a cross connection between them, and except when run in conduit, not less than a foot apart; and not in contact with any substance other than their insulating supports. Wooden blocks to which insulators are attached must be covered over their entire surface with at least two coats of waterproof paint.

For conduit work, wires must be placed so as to conform to rules for unlined conduit except that conduit system must be waterproof (see p. 96).

c. Must be at least seven feet above the highest point of flat roofs (see p. 43) and at least one foot above the ridge of pitched roofs over which they pass or to which they are attached and roof structures must be substantially constructed.

d. Must, where exposed to the weather, be provided with petticoat insulators of glass or porcelain (see pp. 40 and 41); porcelain knobs or cleats and rubber hooks will not be approved. Wires on the exterior walls of buildings must be supported at least every fifteen feet, the distance between supports to be shortened if wires are liable to be disturbed.

Where not exposed to the weather, low potential wires may be supported on glass or porcelain knobs which will separate the wires at least one inch from the surface wired over, supports to be

placed at least every four and one-half feet.

e. Must be so spliced or joined as to be both mechanically and electrically secure without solder (see p. 40). The joints must then be soldered, to insure preservation, and covered with an insulation equal to that on the conductors.

All joints must be soldered, unless made with some form of approved splicing device (see p. 40).

f. Must, where they enter buildings, have drip loops outside, and the holes through which the conductors pass must be bushed with non-combustible, non-absorptive, insulating tubes slanting upward toward the inside.

For low-potential systems the service wires may be brought into buildings through a single iron conduit. The conduit to be equipped with an approved service-head (see pp. 42 and 44). The inner end must extend to the service cut-out, and if a cabinet is required by the Code must properly enter the cabinet.

g. Electric light and power wires must not be placed on the same cross-arm with telegraph, telephone or similar wires, and when placed on the same pole with such wires the distance between the two inside pins of each cross-arm must not be less than twenty-six inches.

h. The metallic sheaths of cables must be permanently and effectively connected to "earth" (see pp. 46-50).

Although not specified in the Code, bare wires are sometimes used, especially through uninhabited and isolated territories, free from other wires (see tables, pp. 62, 63, 210, 211).

Bare wire is also used for high tension wires, the theory being that only the insulators and not the covering are relied on for pole insulation. Hence, where there is no danger of other wires or trees coming near them, bare wire is satisfactory. If there are other wires or trees near, and the tension is below say 5000, then weatherproof insulation saves enough trouble from crosses with other wires, branches, etc., to be worth the cost. When, however, the voltage is above 5000, the protection of the covering is so slight as not to be worth while.

It should be noted that wires should be kept well clear of trees, as branches may blow onto the wires and cause trouble, even if clear of the wires in calm weather.

Also, many companies consider it undesirable to attach wires to trees, but prefer to set independent poles, even at an added expense, on the ground that in the long run the cost is less. Where tree wiring may be necessary, suggestions are illustrated on page 41.

Guard arms should be placed on all corner poles (see pages 40 and 64).

This, however, applies more often to poles on street corners rather than from pole to house.

In alternating current systems the wires in the street are usually of high voltage (2000 to 4000 volts) and a transformer is used for transforming the voltage to 110 or 220 volts.

The rule governing transformer installation is given on page 147.

Current Supply.

Art. 1: In designing a house wiring installation,

it is necessary to know whether the current is direct or alternating and the voltage of the supply service. If alternating it is also necessary to know the phase and cycle.

In some large cities direct current is used and also in places where owners have private generating plants. In most of the intermediate and smaller cities, however, and in practically all suburban districts, the supply is from alternating current.

In practically all residences, except very large ones with large individual motors, the alternating current is delivered in what is known as single phase, requiring but one transformer, and this condition is assumed throughout this section of the book.

The transformer for supplying a residence is generally located on a pole (see p. 49), or in an underground vault, near, or inside, the building and the transformer is designed with two or three wires, according to the system used, coming from it on the house or service side.

The Code rule is as follows:

Transformers must not be placed inside of buildings without special permission.

Must be located as near as possible to the point at which the primary wires enter the building.

Must be placed in an enclosure constructed of fire-resisting material; the enclosure to be used only for this purpose, and to be kept securely locked, and access to the same allowed only to responsible parties.

The transformer case must be permanently and effectually grounded, and the enclosure in which

the transformers are placed must be practically air-tight, except that it must be thoroughly ventilated to the outdoor air, if possible through a chimney or flue. There should be at least six inches air space on all sides of the transformer.

In equipments with not more than fifty lights and outlets many lighting companies deliver the current, from the transformer to the building, on a two-wire system at about 110 volts and without the use of the third or neutral wire.

Voltage.

Art. 2: With the three-wire system the voltage between the two outside wires is generally about 220 volts and the voltage between the neutral (middle) wire and either outside wire is about 110 volts. The 110-volt outlets, for lights and small appliances are placed on two-wire branch circuits, balanced on each side of this neutral wire. Larger appliances are often wound for 220 volts and connected across the outside or 220-volt circuit.

For these larger power appliances and motors 220-volt apparatus is used for the purpose of reducing the size of the wires supplying them. Small heating appliances where considerable heat must be generated are almost universally made for 110 volts.

Bell and telephone systems require but low voltage (4-6 volts) and small currents and therefore are seldom dangerous from a fire standpoint, when kept away from contact with light and power wiring. This portion of the installation is not inspected by insurance representatives, except to see that the wires do not come in contact at any point with

electric lighting or power circuits, from which they must be kept entirely separate.

Service Feeders.

Art. 3: In most of the larger cities the feed wires come directly into the cellar underground and in many cases where the wires are overhead on poles, the owner prefers to have the wires brought into the house underground from the nearest pole, although in this case, the owner must pay for the underground portion of the work.

Where the lighting companies' pole on the highway is not over sixty or seventy feet (60′ or 70′) from the residence, the service company will generally bring its service wires overhead to the house without charge and in such cases it is good practice to have the house wiring carried through the cellar wall to the outside of the house and then rise in a rigid iron conduit to meet the overhead wiring, the end of the conduit being turned over or fitted with an appliance such as a service head or pot-head which will prevent the entrance of water (see p. 44).

At this point, insulators are placed on the side of the house to take the strain of the wires from the pole to the house, and then a loop is made, connecting to the wires in the conduit arranged so that the wires come out of the conduit at a downward angle to prevent rain water from running along the wires into the conduit.

Main Switch and Meters.

Art. 4: The service switch (see pp. 108-112) for cutting off the entire electrical supply of the house and the meters furnished and installed by

the lighting company should be located at some accessible point as in the cellar close to where the wires come through the wall. This makes it unnecessary for the meter reader, who comes once a month, to go through the main living portion of the residence.

Where a different rate is charged for different classes of service there should be a different meter for each class. Many service companies make different rates for light, for power and for heating, cooking and refrigeration. Most companies will furnish and connect 3-wire meters for power and cooking, etc., as well as for light, so that both 110-volt and 220-volt apparatus may be used on the same meter by balancing on each side of the neutral wire, as explained in Art. 2. The service company should be consulted as to meter arrangements.

Current Costs.

Art. 5: The costs given below for operating various appliances are based on the ratio common with many companies throughout the United States, viz:

Lighting, 10c. per kilowatt-hour.

Power, 8c. per kilowatt-hour.

Heating, cooking and refrigeration, 5c. per kilowatt-hour.

Rates varying from the above will cause a like change in the operating costs. Electricity is sold at so much per kilowatt-hour. A kilowatt means 1000 watts (see pp. 195 and 200).

A kilowatt-hour is the equivalent of 1000 watts continually consumed for one hour (see p. 201). Watts (see pp. 195 and 201) are the product of the volts by the amperes. Thus, 40 25-watt Mazda or

Tungsten lamps (each giving about 21 candle-power) all continuously in use for one hour, or one such lamp burning for 40 hours would in either case consume one kilowatt-hour and cost about 10c. at the above rate (see Lamp Data, p. 115).

For cooking, current at 3c. per kilowatt-hour is about the equivalent of artificial gas at 90c.

Grounding.

Art. 6: In two-wire system (see Art. 1), one side of the service switch and in the three-wire system, the neutral (middle) of the service switch (in both cases on the incoming side), should be grounded by means of a copper wire to the water supply pipe on the supply side of the water meter.

By grounding is meant a solid, permanent connection to the earth or ground by means of cennection to water pipes, or plates buried in the ground (see pp. 46-50). The result is that if either outside the house or in it anyone touches this neutral or grounded wire, as at a lamp socket, and also touches or makes connection with the ground, as through a gas pipe or radiator, there is no difference of potential, while if either the positive or negative wire is touched only, the system potential, as 120 or 240 volts, is felt, and is considered perfectly safe while pressures above 300 become dangerous.

Without a ground connection, it is possible, in case of an accident in the street or during a thunderstorm, for almost any pressure to get on the wires. If this happens they are still safe so long as no connection is made by a person between the wires, and no ground connection made at all. If after such dangerous pressure gets on the wires a ground

connection is made somewhere by accident, still nothing happens, but then if a person touch the ungrounded wire and connect to ground, as through a radiator, etc., he gets the full pressure.

On the other hand, with a ground connection made intentionally, whenever any dangerous pressure gets on the wires it immediately flows to the ground, when contact is made, through any lamp socket, motor, or current-using devices on the system, and blows the fuses before any harm can be done.

The result is that a ground connection, while making it possible for any person easily to get the normal voltage, makes it impossible for him to get any more.

Where the wiring of the house is in conduit, the conduit system should be continuous or electrically connected by means of wires, and the conduit system also grounded in the cellar to the water pipe, in the same manner as described above for service switches. The two ground wires should be separate, although they may connect to the same water pipe (see pp. 92-98).

House Mains.

Art. 7: From the service equipment the supply wires, called the mains, should be carried to the central distributing points (known as cut-out or panel equipments), there being one such main for each class of equipment that is separately metered (see Art. 4). These mains are carried to all panel equipments controlling the class of appliance which the mains are intended to supply. The branch circuits which run to light and power outlets and to

the various appliances radiating from these panel equipments, should be located in central and accessible positions. (To find the proper size of wires for carrying any current any distance for any number of lamps, or their equivalent, at any loss of voltage, see table and examples on pages 69 to 78.)

Distributing Panels.

Art. 8: In residence work it is good practice to place the distributing panels in cellars, servants' halls or corridors (not in clothes closets) so that workmen can get to them when necessary without disturbing the occupants of the house, and where possible dirty shoes and hands will do the least damage. The necessity, however, does not often occur in well designed and installed systems.

These panel equipments may consist of groups of porcelain cut-outs and fuses or porcelain base knife switches and fuses. In the best class of work knife switches and enclosed fuses are mounted directly in two vertical rows on polished slate or marble panels and cross connected by metal straps to polished copper bus-bars rising up the middle of the panel. These bus-bars are fitted at their ends with lugs to which the mains connect. The cut-outs or panel are surrounded with slate edgings containing openings through which the circuit wires pass to connect to the branch switches. The slate frame thus formed is mounted in a metal box with from three to four inches (3″ to 4″) space around the slate, thus forming a gutter in which the circuit wires can be carried from the ends of the conduits terminating in the metal box, to the various switches. If a wooden door is used it

should be lined with slate and any wood trim which covers the gutter and overlaps the joint between the box and wall should be lined on the under surface covering gutter with metal. Where metal doors and trims are used only the slate door lining is required. These trims are usually from 24 to 28 inches wide and of varying lengths to suit the number of circuits.

Each panel circuit or switch should be numbered by means of a metal stamp on the bus-bars opposite the switch and a directory sheet should be placed on the inside of the door giving the number of each switch and the number and location of the lights controlled. There should be a separate double pole cut-out or switch and fuses for each circuit consuming 660 watts or less in the case of lamps or small power and heating devices; and a similar cut-out and switch for each outlet for motor, etc., where the capacity is greater than 300 or 350 watts (see Art. 9), (see illustrations, pp. 33-36).

Where more than one main feeds a panel in bus-bar construction, the bus-bars are cut into the required number of sections and each section carried out between switches to the edge of the panel that the main wires may be joined to the bus-bar ends just inside the slate edge and without the necessity of having the wires cross the panel.

To limit the necessity of cutting away too much of walls, floors and supports, where circuit conduits come together, the number of circuits at any panel box should be limited to ten or twelve by placing as many boxes at separate locations as may be necessary to supply the residence. Where the con-

struction will permit, however, as many as eighteen to twenty-four circuits may be grouped at a single panel equipment without undue size.

Branch Circuits.

Art. 9: The rules of the Fire Underwriters allow 660 watts distributed at sixteen sockets on each 2-wire lighting circuit. It is recommended, however, that the number of sockets be limited to twelve or thirteen on a circuit, as this does not greatly affect the cost of the work and will permit the use of No. 14 wire for practically all such branch circuits without undue loss in voltage and without appreciable variation in voltage between outlets on the same circuit under any condition of use. (See Carrying Capacity of Wires, p. 68.)

Branch circuits for single phase power are also two-wire and vary in size depending on the horsepower of the motor or the watts of the appliance connected.

In wiring for small motors from ½ H.P. to 1 H.P. branch circuits should be No. 14 wire for 220-volt motors and No. 12 wire for 110-volt motors. These sizes are made necessary because of the large inrush of current at the moment of starting the motor. For either appliances where there are no moving parts (such as electric soldering iron) the size of the wires vary with the watts consumed, but in no case may such wires be smaller than No. 14 Brown and Sharp gauge (see p. 81, 5th column). Where heating devices are of small capacity (as glue pot and soldering iron in basement workshop) two or more may be placed on one circuit. Where the wattage of a single appliance is 350 watts or more, it is

better to carry a separate circuit to each such appliance.

The branch circuits to electric cooking ranges are generally three-wire; the size depending on the capacity of the range.

The branch circuit for the vacuum cleaner outlets should be on the power section of the system and as but one outlet is used at a time, all the vacuum cleaning outlets in the residence may be placed on one No. 12 wire branch circuit and connected for 220 volts.

Where the lighting companies make separate rates (as in Art. 4) branch circuits to lighting appliances—to power appliances—and to heating appliances must, of course, be kept separate and connected to the proper section of panel equipments.

Knob Work With Flexible Non-Metallic Conduit.

Art. 10: In frame residence with stud partitions, it is permissible to carry wires on porcelain insulators on the sides of the beams and studs and through them by enclosing in porcelain tubes with flexible non-metallic conduit (flexible tube) from nearest knob to outlet, keeping the wires as far as possible from the floor or ceiling to prevent injury. Outlet boxes should be used for flush switches and receptacles; but for ceiling and side fixture outlets where there are no gas pipes and for surface switches and receptacles, wood fixture blocks should be built into the walls and securely fastened to beams and studs to give adequate support for the fixtures and fittings. This type of construction is known as "knob and tube" work and is not only

the cheapest but also a very satisfactory method of installation for concealed wiring (see pp. 91-92).

Armored Cable.

Art. 10a: Some architects and engineers specify armored cable for frame or semi-frame residences (pp. 91 and 101). This armored cable is made by wrapping steel tape or ribbon around the two or more wires of the mains or circuits, thus giving a heavy metal sheathed main or branch circuit. Such cable is made in lengths of from 50 to 250 feet. Armored cable may be laid or drawn between beams and studs or furring strips with practically no liability to mechanical injury from nails, etc. Armored cable should not be placed in brick or concrete walls unless imbedded in plaster-of-paris or other suitable material to protect the sheath and wires from the corrosive action of the surrounding ingredients. For the same reason the best practice prohibits such armored cable being placed in brick or concrete walls where subject to considerable dampness. Outlet boxes in this construction are required at all outlets, and the metal armor should be grounded as called for in Art. 6.

Armored cable construction is very satisfactory in residences where the permanent decorations are not expensive or where the construction is such that the concealed lengths between outlets may be withdrawn and new lengths drawn in (in case of trouble) without injury to the finished surface. This construction is a little more expensive than knob and tube work (see Art. 12).

Flexible Steel Conduit.

Art. 10b: Where the character of a residence is such that it would be expensive to make repairs or alterations in the concealed wiring, good practice calls for the use of concealed conduits for the reception of the wires. These conduits should be large enough to permit the easy drawing in and withdrawal of the wires without the use of tackle. The smallest conduit generally used for electric light branch work is about ½ inch inside diameter (see p. 93). Conduits should be securely fastened to building construction and have easy bends to facilitate the drawing in of the wires. Flexible steel conduit is frequently used for this purpose, the construction of which is practically the same as armored cable but in larger and tube form. These flexible conduits are made in lengths of from 25 to 100 feet for lighting work and this type of wiring installation is more expensive than with armored cable (see Art. 12).

Rigid Conduits.

Art. 10c: For the highest class of residence work, architects and engineers generally specify rigid conduit construction (see p. 92). These rigid conduits are of gas-pipe thickness and are coated on the inside with a tough elastic and very smooth enamel. The exterior may either be coated with the same enamel or galvanized. The conduits come in ten-foot lengths and all diameters from ¼-inch to 6-inch and are joined by means of screw couplings of the same material and the joints are made tight by the use of red or white lead. This prevents the entrance of any moisture. This is the most ex-

pensive character of concealed wiring work (see Art. 12).

Wood Moulding.

Art. 10d: This class of work, which is not permitted in concealed places, is frequently resorted to on account of the cheapness and where it is undesirable, or unnecessary for appearance, to run circuits inside of walls or ceilings. Wood moulding work is especially adapted to the cheaper class of cottages, bungalows, etc. For construction rules see page 88.

Cleat Work.

Art. 10e: In dry places and where the wires are not liable to mechanical injury, or contact with other objects, circuits may be supported on porcelain cleats or knobs.

For this class of work the wires should be separated, by their insulating knobs or cleats, two and one-half inches from each other and at least one-half inch from the surface wired over (pp. 68 and 79), where the voltage does not exceed 300.

Metal Moulding.

Art. 10f: Where it becomes necessary, for mechanical reasons, to use metal moulding the suggestions given on pages 89 and 90 should be followed.

Bell Conduits.

Art. 10g: Bell and telephone cables and wires need not necessarily be in conduit nor need they be installed on knobs. In fireproof or semi-fireproof residences where the cables come in contact with brick or concrete and would not last and in frame residences where it is desired to make re-

pairs to the concealed wiring without injury to the walls, such wires should be placed in concealed conduits, installed in the same manner as described above for electric light wiring. In the best class of residence work this is usually done.

Conduit Fittings.

Art. 11: In both armored cable and metallic conduit construction special fittings are used to connect the metal to the outlet box or cut-out box, or other opening, and in the case of conduit work these bushings and nipples are so designed and installed that the wire is drawn over smooth rounded surfaces to prevent abrasion of the braid covering of the conductors while they are being drawn in (see p. 93).

Approximate Wiring Costs.

Art. 12a: Due to the varied cost of labor and material and to varying methods of building construction, universal costs of electric light work for the several types of wiring hereinbefore described, cannot be given, but for the purpose of general comparison the following approximations may be a help:—

Knob and (Flexible) Tube Work	$1.50 to $2.50	per outlet
B. X. Cable Work	2.00 to 5.00	" "
Flexible Steel Conduit Work	3.50 to 5.50	" "
Rigid Metallic Conduit Work	4.00 to 7.00	" "

It must be borne in mind, however, that these proportions for the wiring work will not follow as proportions for the complete equipment, as the

cost of fixtures, appliances and lamps, etc., will be the same for any one of the systems, and as these fixed costs are generally the larger part of the complete total the above proportions would apply to perhaps one-half or less of the total cost of any given installation.

Bell Costs.

Art. 12b: Bell call or annunciator requirements differ for almost every family and attempts to give costs in this class of work would be misleading. In a general way, however, the equipments will range from $3.00 to $10.00 per call; and from $1.50 to $8.00 per extension bell or annunciator drop. The smaller costs are for the simpler systems with concealed wires not in conduits, and the higher costs for more or less complicated call systems with wires in concealed rigid conduits.

House Telephone Costs.

Art. 12c: A house telephone system intercommunicating between various rooms of the residence and arranged on what is known as metallic circuit connections (to prevent cross-talk) will cost from $20.00 to $50.00 per instrument, depending upon the number and finish of the instruments, and whether or not the concealed wire is in conduit. Most of the telephone manufacturers of this class of instrument make a standard telephone with ten (10) buttons, thus providing for intercommunication between eleven (11) points.

Wire for Light and Power.

Art. 13a: All of the various fire underwriters organizations require "Rubber Covered" wire (see p. 66) for all classes of concealed residence wiring.

These wires may have a single impregnated braid in case of knob and tube work and a double braid in the other classes of concealed work hereinbefore described. The life of rubber insulation depends largely upon the amount of pure unreclaimed Para rubber used in the insulating compound and the method of applying it to the copper conductor. The very best class used in residence wiring as well as the most expensive contains about 30 per cent. pure Para rubber.

In installations supplied by alternating current it is important that all the wires of any branch circuit, main or feeder should be in the same conduit. In fact, this should be absolutely insisted upon to prevent trouble from induction (see p. 91). Joints in wires should not be allowed where they will be concealed in conduits or be at inaccessible points. Where splicing is necessary the joint should first be made mechanically strong, then soldered for perfect electrical contact and insulated with rubber compound and tape and made equal in insulation to the rest of the wire (see p. 68).

Bell and Telephone Wire.

Art. 13b: Wire used in bell and telephone systems may be of the same quality as above described but need not be as large in size. For small bell systems No. 18 B. & S. gauge is amply large for the section wires and No. 16 for the battery wires. These sizes are determined mainly by means of mechanical strength and in order to easily distinguish between battery and section wire.

Where there are a number of bell or telephone wires carried between two points a considerable

distance apart, it is quite customary to buy the cable already made up and these wires are often as small as No. 20 or No. 22 B. & S. gauge. The separate wires in such cables may be insulated with two silk and one cotton wrapping impregnated with beeswax to keep the ends of the yarns from unraveling and the made-up cable encased in a heavy fireproof braided covering.

The most approved type of house telephone contains two wires for each call, two wires for battery talking, two wires for battery ringing. Each pair of wires should be twisted to prevent "cross-talk." This refers to metallic circuit connections in house intercommunicating telephone systems. Where silk and cotton cables are used in damp places the cable should be encased in lead to prevent moisture developing short circuits between the various wires.

Voltage Loss in Conductors.

Art. 14: The size of conductors given in the National Electrical Code for any given current is based only on the safe carrying capacity (see table, p. 81) without undue heating and does not necessarily determine, except where the distance is short, the size of conductor that good engineering practice requires. The proper size of conductors in any installation should be determined by the loss in volts between the service supply and the furthest outlet or appliance (electrically speaking) when the entire equipment is in simultaneous operation. In residence work 2 per cent. loss between the above mentioned points is not excessive (see pp. 69-78). Conductors smaller than No. 14 Brown and Sharp gauge must never be used in electric

light work, except inside the lighting fixtures where a smaller conductor is permissible.

In proportioning the total voltage losses of a residence installation between the mains and branch circuits not more than 1 per cent. loss should be permitted in the branch circuit panel. A simple table, with examples worked out, to show its use, is given on pages 69 to 78. By its use the proper size of wire is easily determined for carrying any current any distance at any desired loss in volts.

There is a large rush of current at the moment of starting up single phase alternating current motors and the loss in such wires should be based on this momentary large amount which may vary from 100 to 200 per cent. overload of current. If this condition is not provided for it is quite possible to install wires that would be large enough to operate the motor after it is in motion, but too small to take care of this starting current (see pp. 22-32).

Room Switches.

Art. 15a: A liberal use of switches in a residence invites economy by encouraging the putting out of lights when leaving rooms. They soon pay for themselves. The most satisfactory switches are of the flush type and should be placed in metal cut-out boxes sunk in the wall and should generally be located just inside of entrance doors.

Large rooms with numerous outlets should be controlled by more than one switch, and in long living rooms it is often a good plan to place the lights of each end of the room on a different switch control, both for convenience of occupants and economy in bills.

For electroliers, switches are sometimes used, so designed that one turn of the handle lights one group of lights; the second turn lighting an additional group without putting out the first group, and a third turn will put all out.

Servants' rooms should have switches and high fixtures not only so that the lights will be more apt to be extinguished when not needed, but also to prevent the use of fixtures as clothes hangers.

Hall Switches.

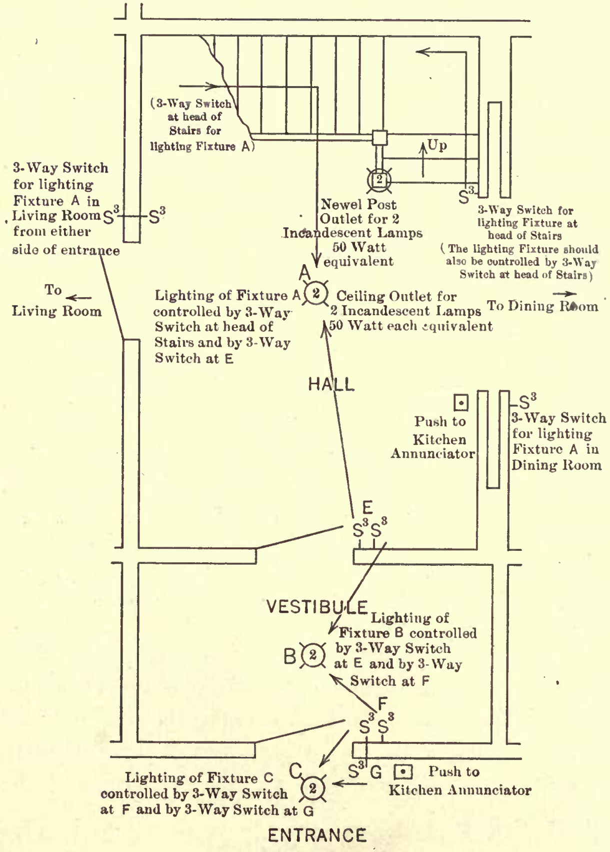
Art. 15b: For hall and stairs it is customary to arrange lights that they may be turned on or off from any one of several switches known as 3-way and 4-way switches. A light in first floor hall and one on the second floor may be controlled by a switch at entrance door and also controlled from second floor. In the same manner an outlet on third floor may be controlled by a switch in second hall and one on third floor. This allows a person going to the third floor to come in late, light halls and stairs to room and put out lights again from above and thus do away with wasteful burning (see Hall Wiring, p. 166).

The three-way arrangement for servants' stairs especially will keep down the monthly bills, because of the ease with which the servants can put out lights. Sometimes this 3-way switch arrangement is used in bedrooms, one switch at door and the other at bed.

Master Switch.

Art. 15c: A master switch may be placed in the owner's bedroom and so connected that the switch will control the first, second and third floors, main

hall and stairs, 3-way lights, either independent of whether the local switches have been used or not (see Master Bedroom, p. 167).



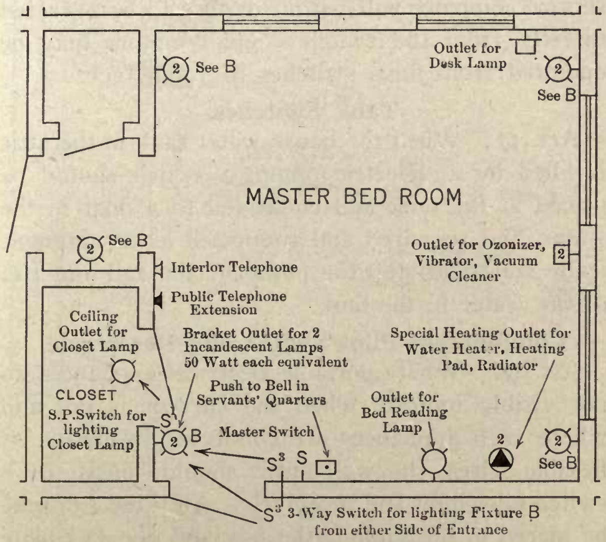
Closet Switches.

Art. 15d: Closet switches are often controlled by switches set in the door jambs and operated by

movement of door. As closets, however, are often left open for ventilation, wall switches are preferable (see cut of closet below).

Pilot Switches.

Art. 15e: With switches operating lights not visible from the switch (as in case of cellar) it is



economical to equip the switch with a small pilot light which burns when switch is in use.

This same style of pilot switch should be used in connection with all heating or other appliances which are fixed in position and do not visibly indicate when current is on (see Art. 18).

Motor Switches.

Art. 16: Fused knife switches (see p. 112) in

metal boxes should be used in connection with A. C. motors of ½ H.P. and larger. These switches should be double pole and located near the motor they control. Motor starting boxes are sometimes used with ½ H.P. to 1 H.P. A. C. single phase motors in order to cut down the momentary rush of current (described in Art. 14), but nearly every service company will permit motors to be operated directly from the switch. Small motors may be operated from flush switches of room type.

Tank Switches.

Art. 17: When the house water tank in the attic is filled by an electric pump, a switch should be placed at the tank and connected to a float in the water, and so wired and connected as to automatically start and stop the pump by the fall and rise of the water in the tank.

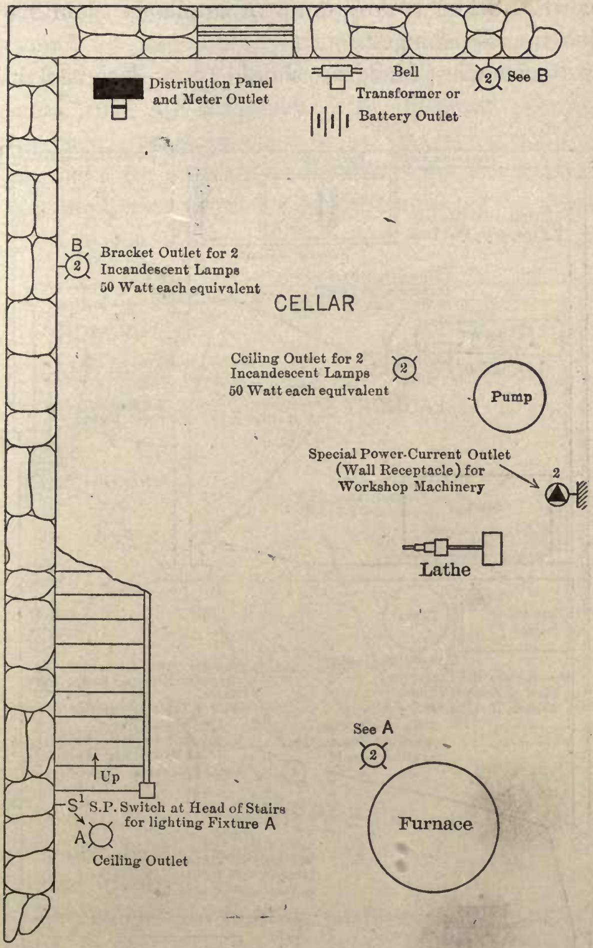
Combination Pilot Switch and Receptacle.

Art. 18: Where portable electrical appliances do not visibly indicate when the current is on, and where such appliances are connected by means of flexible wires, the wall outfit should consist of a switch pilot light and receptacle. All three (3) may be placed in the same outlet box and one (1) plate covers all.

Base Receptacles.

Art. 19a: Flush receptacles and plugs should be liberally distributed throughout the residence as they are very handy for a great variety of purposes and may be generally placed on or just above the baseboard. The plates may be painted to match surroundings and made very inconspicuous.

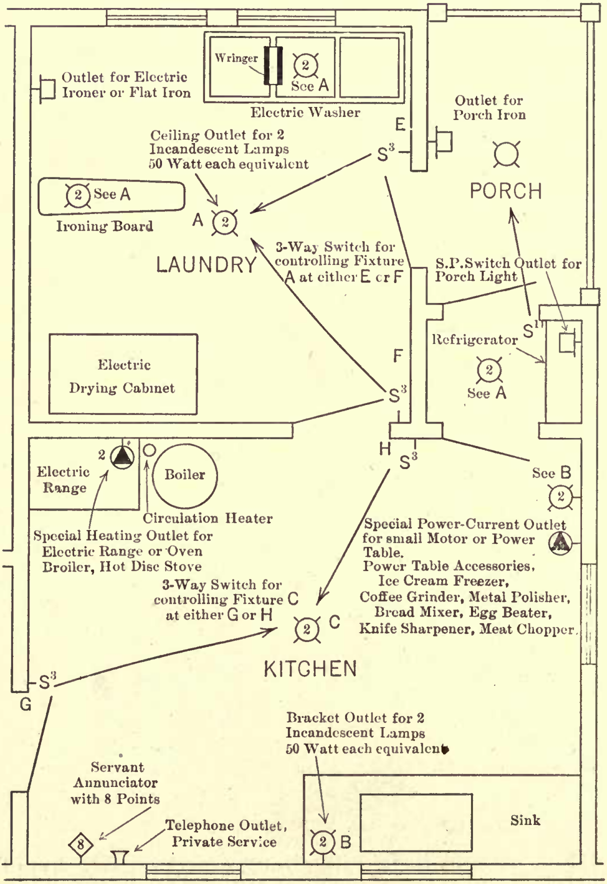
Receptacles for the same voltage and class of



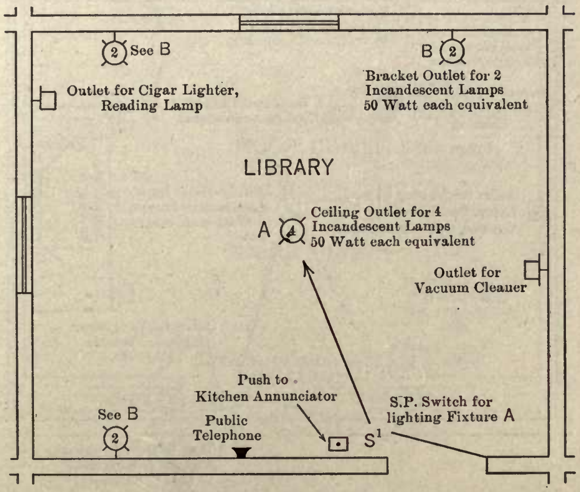
service should have interchangeable plugs to avoid the necessity of changing the plug on the flexible

cord attached to any lamp or appliance should its location be changed.

Receptacles, however, should be so designed that



the plugs on apparatus of different voltage or class cannot be inadvertently connected to wrong receptacles. This may be accomplished by using the same make of receptacle with different openings for each voltage or class or by specifying a different make for each class. If this is not done, a 110-volt appliance might be easily connected to a 220-



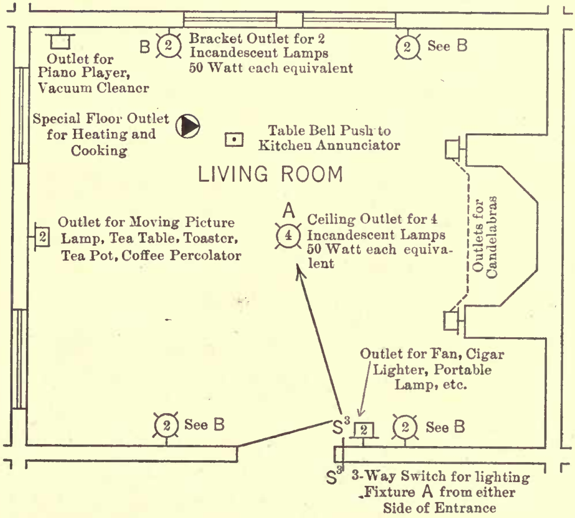
volt receptacle in which case the appliance would probably be destroyed to say nothing of the fire hazard involved.

Receptacles for lighting purposes are usually 110 volts.

In addition to the lighting receptacles which are usually installed for reading lamps, piano lamps, etc., there should be one or two spare receptacles

in each main room and hall. One of the receptacles in main living room or hall should be placed so as to be near a suitable location for a Christmas tree, so that this may be illuminated without unsightly wires showing in the room.

A porcelain lamp receptacle, mounted in a condulet or outlet box, is often placed under the

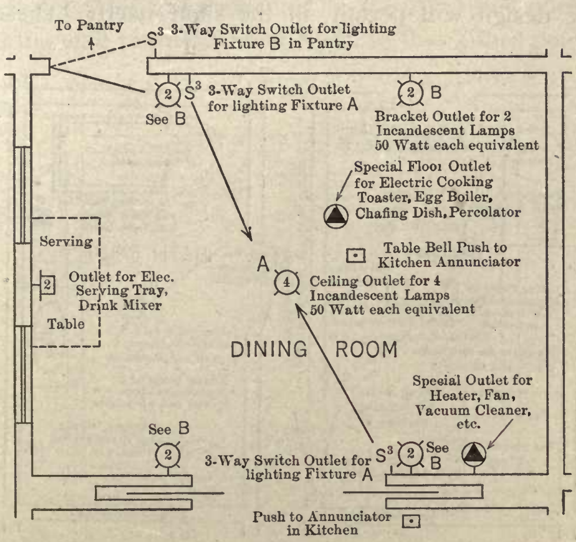


kitchen range-hood and the conduit run around under the hood to the side wall where the controlling switch is located.

Outdoor Decoration Receptacles.

Art. 19b: A waterproof receptacle and plug should be located outside the main entrance, controlled by a switch in hall for step and walk canopy lighting.

A similar receptacle and plug may be placed high up on pillar or wall of porch for electric decorations. These receptacles should be on a separate circuit from panel and controlled by a switch at porch door.



Porch Receptacles.

Art. 19c: The living porch should have one or more flush wall receptacles placed in the side wall twelve or fifteen inches above the floor (to prevent water splashing on them). These receptacles for use of reading lamp, chafing-dish, percolator, etc.

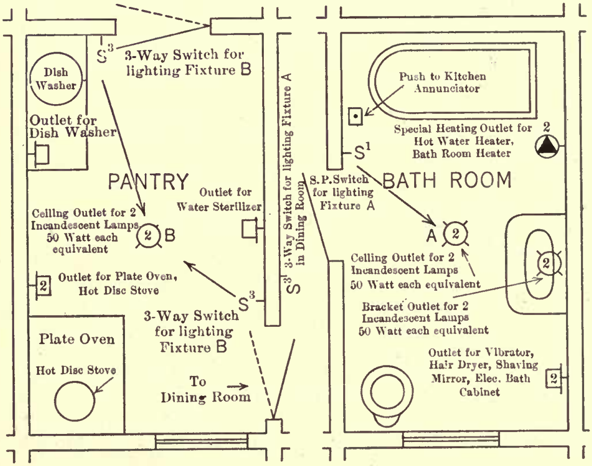
Bedroom porches may have a similar receptacle for reading light.

Servants' or kitchen porches should have a re-

ceptacle pilot light and switch (see Art. 18), so that ironing may be done on the porch in hot weather. Should a receptacle should be on a separate circuit.

Mantel Receptacles.

Art. 19d: Receptacles for mantel candles may be placed in the wall just above the shelf, or, where the design will permit, in the shelf itself. These

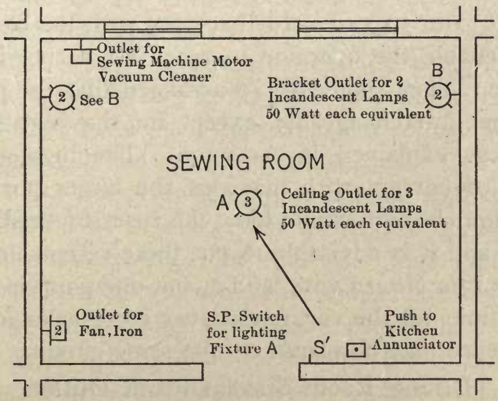


receptacles should be controlled by a switch at convenient location.

Bed Receptacles.

Art. 19e: Two receptacles, one for reading lamp and one for heating pad or similar sick room appliance, should be placed at the side of each bed and connected to 110-volt lighting circuit. These may both be in the same outlet box and covered with one plate. Alongside of this equipment but not in con-

tact with same, may be placed a bell receptacle with removable portable cord and hand "pear push" for bell call. This bell receptacle and plug must be of entirely different design from the two before mentioned so that by no possibility may the bell plug be attached to either of the other receptacles. These bell portables are connected to the same bell wires as the wall push button at door, so that either point



rings the same bell or drop on the annunciator.

Floor Receptacles.

Art. 19f: Where receptacle outlets come in the floor, they should be placed in specially designed floor boxes which have cone shaped tops projecting above the floor to prevent water entering the box and to protect the wires. When these portables are not in use, the cone top can be removed and a flush top substituted.

Stereopticon Receptacles.

Art. 20: Stereopticon and moving picture machines are now made for home use. The receptacles for some have a larger capacity than those for lighting and are usually placed at the end of the long living room or hall. They should be connected to 110-volt power and by means of two No. 8 wires.

Vacuum Cleaner Receptacles.

Art. 21: Flush receptacles for portable vacuum cleaners should be so located that the thirty to fifty feet (30 to 50′) of cord that goes with the cleaner will enable the operator to reach all parts of the house. They should be so arranged that the plugs are not interchangeable, except for the very small type as explained in Art. 19a. The momentary rush of current with many of the larger portable vacuum cleaners would blow the fuses of small circuits and it is advisable to put these receptacles on a separate No. 12 wire, and as but one point is used at a time, all the vacuum cleaner receptacles in the residence may be placed on the same circuit.

Dining Room Special Front Outlet.

Art. 22: There should be a receptacle and outlet box placed in the floor under the dining-room table, a little off the center, so as to clear the center leg of table. This should be fitted with a removable plug connected to permanent table wiring (which is carried up the center leg of the table along the under framework and out on the crossbars, where the wiring should terminate in three 110-volt fused power receptacles. One of these may be used for electric chafing-dish or egg boiler, one for electric toaster and one for electric coffee percolator. This enables

the housewife to use the above appliances and disconnect and remove them as desired, without reaching to the floor and with practically no exposed connections, except the short ones over the edge of the table. The three receptacles under the edge of the table may, if desired, be mounted in a neat box to match the woodwork. (See Dining Room, p 173.)

Other Power Receptacles.

Art. 23: Flush receptacles for power and heating appliances are of sizes depending on capacity, but for most residence work, the standard 10 ampere receptacle and plug manufactured by many companies, is satisfactory in the great majority of cases. For different classes of apparatus and voltage, these receptacles should not be interchangeable (see Art. 19a). For use with heating or similar appliances, they should be in connection with pilot lights and switches, as explained in Art. 18. This type of combined switch and receptacle should be used for laundry and pressing irons (and provision should be made at ironing table to hold up the cord connecting the iron). A laundry iron receptacle should always be placed to the right of the laundress.

Cellar Lighting.

Art. 24: Usually 10 or 15 watt lamps are sufficient for cellar lighting except in case of work bench or lathe, which should be brightly lighted by 25 watt or 40 watt lamps.

Outlets should be so located as to illuminate sinks, furnaces and any pumps or apparatus that need attention. Store rooms and vegetable rooms should be well lighted from ceiling with controlling switch at door. The wine room switch should pref-

erably be placed outside the door, so that the room may be inspected through glass or grating of door without unlocking.

There should be at least one outlet in cellar controlled by pilot switch at the head of the stairs (see Art. 15e), and where there are few lights in the cellar it is sometimes advisable to put all on such a switch. (See Cellar, p. 169.)

Porch Lighting.

Art. 25: Porches are usually lighted from ceiling outlets controlled by a switch at porch door with receptacles for reading lamps, etc. (See Art. 19c. (See Porch, p. 170.)

Room Lighting.

Art. 26: In addition to mantel lights (see Art. 19d), side or ceiling lighting should be so designed as to properly illuminate all portions of a room (see pages 114-119), in such a manner as to allow the shifting of furniture from time to time without destroying the harmony of the interior. For this reason residence outlets should not be limited to the fewest possible permissible with the original furniture layout, but should be planned with a view of any re-arrangement of furnishings. Outlets not needed with first scheme may be capped until required. For economy as well as for convenience, room lighting should be controlled by switches (see Art. 15a). Most rooms require one or more receptacles for portable lights (Art. 19).

A cigar lighter may be placed on the lighting circuit of den or living room. It uses very little current and does away with burnt matches. It needs no switch beyond the self-contained one.

Dining room—the table should be well lighted by ceiling domes or showers.

For bedrooms, in addition to the above room lighting, there should be a receptacle for desk lamp and there should also be a reading lamp at bed. (See Art. 19e.)

Hall Lighting.

Art. 27: Halls require a soft general illumination and the addition of portable table and vase lights is often advantageous. In addition to the wall switches for the regular lights, there should be up and down control between floors as mentioned in Art. 15b. (See Hall, p. 166.)

Pantry Lighting.

Art. 28: The pantry should be well lighted from a high center outlet so that contents of dressers and cupboards may easily be seen and this outlet should be controlled by a switch. (See Pantry, p. 174.)

Kitchen Lighting.

Art. 29: Kitchens are generally lighted from ceiling outlet controlled by switch at door. When, however, there are appliances around side wall at which the cook works, there would be a shadow if only the center fixtures were used, and side outlets should be added at such points and at the sink. The range-hood should have a light under same, as detailed in Art. 19a. (See Kitchen, p. 170.)

Laundry Lighting.

Art. 30: Laundries are usually finished in light color and need comparatively little general illumination from ceiling fixture controlled by a switch at door. A drop light should be provided at ironing

table and a side light at laundry machine. (See Laundry, p. 170.)

Bath Room Lighting.

Art. 31: Most bath rooms may be well lighted by means of a 2-light ceiling fixture or side outlets placed over the mirror, the fixtures projecting 8 to 15 inches from wall and with two inverted lights in such position as to light top of head and each side of face, controlled by a switch at door. Bath room lights should never be so placed as to throw the shadow of anyone in the room on the window shade. (See Bath Room, p. 174.)

Sewing Room Lighting.

Art. 32: The general illumination of the sewing room may be from the ceiling with switch control. Side lights should be installed to brightly illuminate the sewing machine and cutting table and also the chair used for hand sewing. An outlet for electric pressing iron (see Art. 32), should be installed and when the room is used in hot weather an electric fan adds to comfort. An 8-inch fan takes very little current—20 to 40 watts, and can be used on lamp socket. (See Sewing Room, p. 175.)

Closet Lighting.

Art. 33: Closet lights are desirable unless room fixtures are so placed as to illuminate them. Especially is this true of storage and servants' closets as it insures cleanliness. Closet lights should be controlled by wall or door switches. (See Art. 15d.) (See Closet, p. 167.)

Play Room Lighting.

Art. 34: The play room should be brightly lighted from the ceiling and controlled by a switch at door.

This will prevent accidents to or from low side fixtures. The play room should also be wired for use as a bedroom with side lights and receptacles with outlets capped up for future use. If receptacles for play toys are installed they should be of such a character as not to permit the toys being connected to other outlets.

Servant Room Lighting.

Art. 35: It pays to light servants' room from high ceiling lights designed for wide distribution of lighting and install switch at door for control of same. The lights will be thus used more economically and the fixtures cannot be carelessly mishandled.

Workshop Lathe.

Art. 36: Many owners like to provide a small workshop for their own use. A small wood turning lathe can be operated by a motor consuming about 200 watts. This lathe may be controlled by either a motor starter and switch, or by means of a switch only, as detailed in Art. 16. (See Cellar, p. 169.)

House Pump.

Art. 37: Where city water supply is not available and a well is used, a tank located on roof or attic can be filled by electric pump. The well pipe may be from 1½-inch diameter up, depending on the quantity of water needed. The motor may be controlled by hand or it may be automatic in action, as noted in Art. 17. (See Cellar, p. 169.)

If wiring is installed a double throw switch is usually placed in the basement or at the pump to permit hand operation so that tests may be made

from time to time to see that everything is working satisfactorily. Water cocks may be placed around the lawn and water pumped through them directly for watering lawn, or for fire purposes without using up the water in the tank.

Refrigeration.

Art. 38: Where ice is expensive or difficult to obtain, an ice box refrigerator electrically operated can be installed. These outfits require little attention and in addition to keeping the box cool, can be used to make a small amount of ice for table and sick room use.

Stereopticon.

Art. 39: Stereopticon and moving picture machines are now made for residence use and are fast becoming an important part of the equipment of every home, especially where there are young people. Special receptacle should be provided as detailed in Art. 20.

Vacuum Cleaner.

Art. 40: Portable vacuum cleaners are well known and much used. They should not be connected to the branch circuits feeding lights and small appliances (see Art. 9), but should be provided with a special circuit and their own outlets. (See Art. 21.) Sometimes a permanent machine is installed in the basement with pipes carried concealed in the walls and with convenient outlets on each floor to which hose may be attached. In such a case it is advisable to place near the motor an automatic distant control switch and carry one No. 14 wire branch circuit to flush receptacles placed close to each hose outlet. The plug is attached to the

end of the hose with a small chain. The connections are such that when the hose is in use and the plug inserted into the receptacle, the cleaner will start up and when the hose is removed thus pulling out the receptacle plug the motor stops, preventing waste of current. The receptacles that are used for connection to portable machines and their circuit are not used in this case.

Plate Warmer.

Art. 41: Plate warmers are very convenient and add much to the ease of service and success of dinners. They may be placed under dressers or pantry table and should be fitted with 2 or 3 heat switch and pilot light. When the first set of cold plates is placed in warmer, the switch is turned to high heat and left on for fifteen (15) minutes, when the lower heat is turned on and keeps the contents hot.

Dish Washer.

Art. 42: Electric dish washers are of many makes—occupy small space—do their work quickly and well and need little attention. They may be fitted with a switch on machine or at wall. (See Art. 16.)

Metal Polisher.

Art. 43: An electric silver and metal polisher consists of a ¼ h.p. or ½ h.p. or larger. The ends of the motor shaft are arranged to receive various brushes, buffers, felt wheels and other fittings, all of which can be obtained with the outfit. By using such a machine the knives, forks, spoons and silverware may be kept in the best condition with a small expenditure of time and energy. Should have

switch and receptacle on wall, omitting pilot light. (See Art. 18.)

Ice Cream Freezer.

Art. 44: An electric ice cream freezer insures the best and purest home product with but little trouble. The electric current expense is negligible. Should have switch on machine with receptacle on wall or combined switch and receptacle on wall, omitting pilot light. (See Art. 18.)

Electric Cooking Range

Art. 45: Cooking by electricity is fast coming into more general use. The freedom from odors and escaping gas, the cleanliness and the application of heat only where needed, appeals strongly to the housekeeper and in many parts of our country, such cooking may now be done as cheaply as with gas. (See Art. 5.)

An electric range for a family of six would occupy a floor space of about 22 inches by 28 inches. It is generally fitted with a number of separate switches for the various parts and utensils and should be on a separate 3-wire feeder with 3-pole main switch and pilot light. (See Kitchen, p. 170.)

Ironing Table.

Art. 46: Laundry ironing tables may be purchased complete with swinging arms to take care of the cords and with two (2) irons for different classes of work and so arranged with automatic stands that the iron when not in actual use takes only enough current to keep it hot. (See Art. 23.)

Clothes Washer and Wringer.

Art. 47: The simplest type of electric clothes washer and wringer may be mounted on the tubs

and removed when not in use. Other types have all parts mounted on one stand which may be on rollers to bring it to the tubs on wash days and remove it at other times. Such a machine for a family of six would occupy a floor space of about 28 inches by 32 inches and the washing would be done better than by hand and with no danger of tearing laces and lingerie. Has switch on the machine and should connect to receptacle on wall. (See Laundry, p. 170.)

Starch Cooker.

Art. 48: A convenient and inexpensive appliance in the house laundry is an electrically heated pot for cooking starch. Should be connected to pilot switch and receptacle. (See Art. 18.)

Sewing Machine Motor.

Art. 49: Every home should have the sewing machine fitted with a motor which may be very small in size and can be arranged to start and stop by pressing a contractor with the foot. It is very inexpensive to operate and saves many a doctor's bill where much sewing is done. The motor may be 110 volts and should be connected to a base receptacle.

Bath Room Heater.

Art. 50: Heating rooms by electricity is not yet an economic fact, but for special cases where not in continual use, they are very convenient and not too expensive to operate. When taking a bath on a winter morning when the hot water is turned on an electric heater may also be turned on and by the time the tub is ready, the chill will be taken out of the air. For this purpose the heaters should have

a capacity of four watts per cubic foot of room, although this is much greater than would be needed for continuous heating. These heaters should be on separate circuits and be supplied with combination pilot switches and receptacles. (See Art. 18.) (See Bath Room, p. 174.)

Other Bath Room Appliances.

Art. 51: Curling iron heaters may be mounted on the surface of the wall and are very small in size and consume current only when the iron is inserted into the heater. Hot water cups or stoves are much used, take up little space and should be connected to a combination pilot switch and receptacle. (See Art. 18.)

Entrance Ball Calls.

Art. 52: The push button at the main entrance door should not ring on the annunciators, but should be a distinctive call, ringing a separate bell in kitchen or pantry. An extension bell should be placed in servant's room or corridor and a second extension may be placed in a sewing room that is much used. These extensions are controlled by small lever switches for cutting them off in time of sickness. The push button at rear entrance should ring a buzzer in the kitchen, but without the extensions.

Bell Annunciators.

Art. 53: An annunciator should be placed in the kitchen with bell different in sound from adjacent bells and fitted with an indicating drop from each of the rooms, porches and baths in the house.

A second annunciator is often placed in servants' corridor and a third annunciator may be placed in the sewing room.

These two or three annunciators ring and indicate simultaneously for each call and are connected together by two or three wires more than the total number of calls or drops on each.

When a call is answered from any annunciator, a push at bottom of the annunciator resets all the annunciators, thus letting others know that the call is being attended to.

Wall Pushes.

Art. 54: Wall pushes are placed in the door trims of the various rooms, porches, bath, etc., and connected to the nearest annunciator. Bath room pushes are sometimes placed over tub rather than at the door.

Table Pushes.

Art. 55: In some rooms such as the living room, it is often desirable to have a table push on a flexible cord connected to a floor receptacle. These portable pushes are usually connected to the same wires as the wall push in such rooms. In case of the dining room, the table push rings a separate buzzer in the pantry while the wall push rings the annunciator.

Bed Pushes.

Art. 56: Portable push buttons are frequently located at beds and they connect to the same wires as the wall pushes. (See Art. 19e.)

When the mistress of the house has a special maid, her bed portable push is usually connected to a buzzer in the maid's room.

Battery and Cabinet.

Art. 57: The bell system may be operated from six to eight cells of dry battery, placed in a cabinet

which may be located in the cellar. It is often well to use these batteries in duplicate with a throw-over switch so that while one set is being replaced or renewed, the other set is in use. (See Cellar, p. 169.)

Bell Ringing Transformer.

Art. 58: Where alternating current is used for lighting, the bell system can be operated by a small bell ringing transformer which may be placed in the cellar and connected to one of the lighting circuits. These transformers may also be used for house intercommunicating telephone ringing, when the telephones are on metallic circuit. They cannot be used for telephone talking, which requires battery or direct current. (See Cellar, p. 169.)

Public Telephone.

Art. 59: It is quite usual to put conduits in a residence for use of the Public Telephone Co. and thus keep their wires out of sight. A Public Telephone outlet may be placed in the kitchen or pantry with extensions to living room, owner's bedroom and to still other points if desired. A ¾-inch conduit is ample for the above equipment.

Standard Wiring Symbols.

Art. 60: Owners, architects and contractors would save much time and misunderstanding by familiarizing themselves with, *and using,* the standard symbols as recommended by The National Electrical Contractors' Association and The American Institute of Architects, when indicating on plans just what is desired in the way of outlets, fixtures, receptacles, etc., etc., as given on the next page.

STANDARD SYMBOLS FOR WIRING PLANS

As adopted and recommended by The National Electrical Contractors Association of the United States and The American Institute of Architects

Ceiling Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Ceiling Outlet; Combination. 4/2 indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

If gas only.

Bracket Outlet; Electric only. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Bracket Outlet; Combination. 4/2 indicates 4-16 C. P. Standard Incandescent Lamps and 2 Gas Burners.

If gas only.

Wall or Baseboard Receptacle Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Floor Outlet. Numeral in center indicates number of Standard 16 C. P. Incandescent Lamps.

Outlet for Outdoor Standard or Pedestal; Electric only. Numeral indicates number of Standard 16 C. P. Lamps.

Outlet for Outdoor Standard or Pedestal; Combination. 6/6 indicates 6-16 C. P. Standard Incandescent Lamps; 6 Gas Burners.

Drop Cord Outlet.

One Light Outlet, for Lamp Receptacle.

Arc Lamp Outlet.

Special Outlet, for Lighting, Heating and Power Current, as described in Specifications.

Ceiling Fan Outlet.

S^1 S. P. Switch Outlet.

S^2 D. P. Switch Outlet.

S^3 3-Way Switch Outlet.

S^4 4-Way Switch Outlet.

S^D Automatic Door Switch Outlet.

S^E Electrolier Switch Outlet.

Show as many Symbols as there are Switches. Or in case of a very large group of Switches, indicate number of Switches by a Roman numeral, thus: S^1 XII, meaning 12 Single Pole Switches.
Describe Type of Switch in Specifications, that is,
Flush or Surface, Push Button or Snap.

Meter Outlet.

Distribution Panel.

Junction or Pull Box.

Motor Outlet; Numeral in center indicates Horse-Power.

Motor Control Outlet.

Transformer.

Main or Feeder run concealed under Floor.

Main or Feeder run concealed under Floor above.

Main or Feeder run exposed.

Branch Circuit run concealed under Floor.

Branch Circuit run concealed under Floor above.

Branch Circuit run exposed.

--●----●-- Pole Line.

● Riser.

Telephone Outlet; Private Service.

Telephone Outlet; Public Service.

Bell Outlet.

Buzzer Outlet.

2 Push Button Outlet; Numeral indicates number of Pushes.

Annunciator; Numeral indicates number of Points.

Speaking Tube.

Watchman Clock Outlet.

Watchman Station Outlet.

Master Time Clock Outlet.

Secondary Time Clock Outlet.

Door Opener.

Special Outlet, for Signal Systems. as described in Specifications.

Battery Outlet.

Circuit for Clock, Telephone, Bell or other Service, run under Floor, concealed. Kind of Service wanted ascertained by Symbol to which line connects.

Circuit for Clock, Telephone, Bell or other Service, run under Floor above, concealed. Kind of Service wanted ascertained by Symbol to which line connects.

NOTE—If other than Standard 16 C. P. Incandescent lamps are desired, Specifications should describe capacity of Lamp to be used.

When in Doubt.

Art. 61: Be guided by the sections on "Approved Apparatus and Supplies" (page 135), and by "Electrical Inspection" (page 140).

Resuscitation From Electric Shock.

As recommended by The National Electric Light Association. Follow these instructions even if victim appears dead.

I. Immediately Break the Circuit.

With a single quick motion, free the victim from

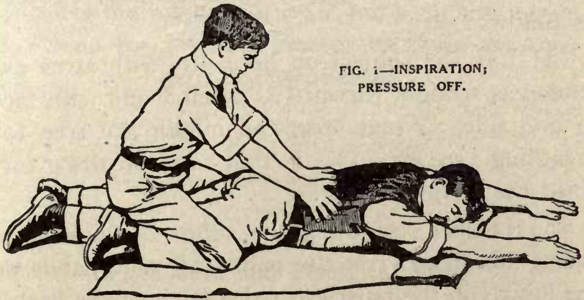


FIG. 1—INSPIRATION; PRESSURE OFF.

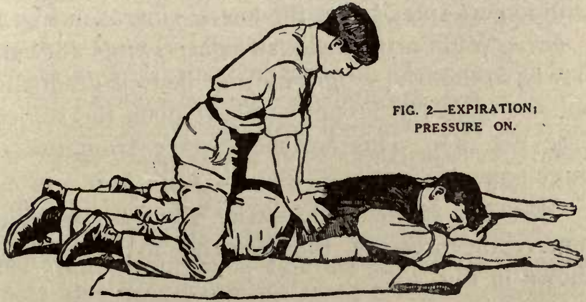


FIG. 2—EXPIRATION; PRESSURE ON.

the current. Use any *dry non-conductor* (clothing, rope, board) to move either the victim or the wire. Beware of using metal or any moist material. While freeing the victim from the live conductor have every effort also made to shut off the current quickly.

II. Instantly Attend to the Victim's Breathing.

As soon as the victim is clear of the conductor, rapidly feel with your finger in his mouth and throat and remove any foreign body (tobacco, false teeth, etc.). Then *begin artificial respiration at once.* Do not stop to loosen the victim's clothing now; *every moment of delay is serious.* Proceed as follows:

(a) Lay the subject on his belly, with arms extended as straight forward as possible and with face to one side, so that nose and mouth are free for breathing (see Fig. 1). Let an assistant draw forward the subject's tongue.

(b) Kneel straddling the subject's thighs, and facing his head; rest the palms of your hands on the loins (on the muscles of the small of the back), with fingers spread over the lowest ribs, as in Fig. 1.

(c) With arms held straight, swing forward slowly so that the weight of your body is gradually, but *not violently,* brought to bear upon the subject (see Fig. 2). This act should take from two to three seconds.

(d) Then immediately swing backward so as to remove the pressure, thus returnig to the position shown in Fig. 1.

(e) Repeat deliberately twelve to fifteen times a minute the swinging forward and back—a complete respiration in four or five seconds.

(f) As soon as this artificial respiration has been started, and while it is being continued, an assistant should loosen any tight clothing about the subject's neck, chest, or waist.

2. Continue the artificial respiration (if necessary, two hours or longer), *without interruption,* until natural breathing is restored, or until a physician arrives. If natural breathing stops after being restored, use artificial respiration again.

c. *Do not give any liquid by mouth until the subject is fully conscious.*

4. Give the subject fresh air, but keep him warm.

III. Send for Nearest Doctor as Soon as Accident is Discovered.

Switchboard and Electrical Fires

A liquid extinguisher, called Pyrene, has recently been put on the market. Experiment and acceptance tests made by the largest electric light, power, railroad and transit companies in America and by the underwriters laboratories, indicate that it is of great value to the electrical industry. At several of the tests made short-circuit electrical arcs larger than any that have ever before been intentionally produced, were successfully handled by this extinguisher, arcs of an indicated energy of 400-h.p. being snuffed out by a few ounces of the liquid. It was also found difficult to re-establish the arcs when put out by this preparation.

The extinguisher is small and light, working on the principle of a double-acting syringe, can be conveniently located and is easily carried. As the liquid will not freeze at 60° below zero it can be left in exposed places during the winter. No periodic recharging is required, although they are refillable after use.

MISCELLANEOUS.

DEFINITIONS OF ELECTRICAL UNITS.

All electrical units are derived from the following mechanical units:

The Centimeter is the unit of length, and equals .3937 inch, or .000000001 of a quadrant of the earth.

The Gram is the unit of mass, and is equal to 15.432 grains, the mass of a cubic centimeter of water at 4° C.

The Second is the unit of time and is the time of one swing of a pendulum, swinging 86464.09 times per day, or the 1/86400th part of a mean solar day.

The Volt is the unit of electro-motive force [E].

Electromotive force, which is the force that moves electricity, is usually written E. M. F. (in formulæ E) and various writers use it to express potential, difference of potential, electric pressure and electric force.

One volt will force an ampere of current through one ohm of resistance. Its value is purely arbitrary, but fixed.

The Ohm is the unit of resistance [R] and it is equal to the resistance of a column of pure mercury 1 square millimeter in section and 106.3 centimeters long at the temperature of melting ice.

One ohm is that resistance through which one ampere of current will flow at a pressure of one volt of E. M. F.

The Megohm = 1,000,000 ohms.

The Ampere is the unit of current strength [C]. Its value may be defined as that quantity of elec-

tricity which flows through one ohm of resistance when impelled by one volt of E. M. F.

One ampere of current flowing through a bath will deposit 0.017253 grain of silver or 0.004085 grain of copper per second.

The Coulomb is the unit of quantity [Q], and is the quantity of electricity passing per second, when the current is one ampere.

The Farad is the unit of capacity [K], and is capacity that will contain one coulomb at a potential of one volt.

A condenser of one farad capacity, if charged to two volts, will contain two coulombs; if to 100 volts, 100 coulombs, etc.

The Microfarad [mfd] = one millionth of a farad.

The Joule is the unit of work [W]. It is the work done or heat generated, by a watt in a second. It is equal to .7373 foot-pound.

The Watt is the unit of electrical power [P], is the energy contained in a current of one ampere with an electromotive force of one volt. 746 watts = one horsepower. A current of 7.46 amperes at 100 volts will do the work of the one horsepower.

A Horse-Power in a steam engine or other mover is 550 lbs. raised one foot per second, or 33,000 lbs. one foot per minute.

The Kilowatt [kw] equals to 1,000 watts.

The E. M. F. is distributed according to the resistance of the various parts of the circuit, except where there is counter E. M. F.

Counter E. M. F. is like back pressure in hydraulics. Thus, to find the available E. M. F., or

the resulting current against a resistance where there is a counter E. M. F., the counter E. M. F. must be deducted. For example: Suppose a storage battery with a resistance of .02 ohm and a C. E. M. F. of 15 volts, and you wish to charge it with a dynamo which gives an E. M. F. of 20 volts at the battery binding posts. There are 20 — 15 = 5 volts working through a resistance of .02 of an ohm with consequently a current of 250 amperes. The impressed voltage is, however, 20 volts, and not 5 volts, and the power is 20 × 250 = 5000 watts, and not 5 × 250 = 1250 watts, as might perhaps be supposed. It is obvious that the C. E. M. F. has acted as a true resistance. In the above case 5 × 250 = 1250 watts were wasted in overcoming the resistance of the storage battery and the remaining 3750 watts were stored up in the chemical changes which they brought about in the active material of the storage battery.

Mils = Thousandths of an inch.

d^2 = circular mils.

The Circular Mil is now generally used as the unit of area when considering the cross-section of electric conductors, the resistance being inversely, and weight of copper directly, proportion to the circular mils.

General Formulae Ohms Laws (Direct Current.)

C. = current in amperes.

E. = electromotive force in volts.

R = resistance in ohms.

W. = energy in watts.

$$C. = \frac{E.}{R.} \qquad E. = C.R. \qquad R. = \frac{E.}{C.}$$

$$C.\,E. = W. \qquad W. = \frac{E^2}{R} \qquad C^2\,R. = W.$$

$$\frac{W.}{746} = H.P. \qquad W. = 746 \times H.P.$$

Formulæ giving the volts or amperes necessary for a given horsepower on circuits of constant current, and constant potential, respectively:

$$E. = \frac{746 \times H.P.}{C. \times K.}$$

$$C. = \frac{746 \times H.P.}{E. \times K.}$$

E. = potential of circuit.
C. = amperes.
K. = efficiency of machine.
H.P. = horsepower.

General Formulae for Direct Current Light and Power Wiring. When possible use the tables on pages 52 and 69, for conveniences.

c.m. = circular mils. (See page 81).
d. = length of wire, in feet, on one side of circuit.
n. = number of lamps in multiple.
c. = current in amperes per lamp (see p. 115).
v. = volts lost in lines (see pp. 32 and 70).
r. = resistance per foot of wire to be used.
10.8 ohms = resistance of one foot of commercial copper wire having a diameter of one mil and a temperature of 75° Fahrenheit.

It is an easy matter to find any of the above values by the following formulæ for direct current:

$$\text{c.m.} = \frac{10.8 \times \text{2d.} \times \text{n.} \times \text{c.}}{\text{v.}}$$

$$\text{v.} = \frac{10.8 \times \text{2d.} \times \text{n.} \times \text{c.}}{\text{c.m.}} \qquad \text{c.} = \frac{\text{c.m.} \times \text{v.}}{10.8 \times \text{2d.} \times \text{n.}}$$

$$\text{n.} = \frac{\text{c.m.} \times \text{v.}}{10.8 \times \text{2d.} \times \text{c.}} \qquad \text{2d.} = \frac{\text{c.m.} \times \text{v.}}{10.8 \times \text{c.} \times \text{n.}}$$

$$\text{r.} = \frac{\text{v.}}{\text{n.} \times \text{c.} \times \text{2d.}}$$

$$\text{v.} = \text{n.} \times \text{c.} \times \text{2d.} \times \text{r.} \qquad \text{c.} = \frac{\text{v.}}{\text{2d.} \times \text{n.} \times \text{r.}}$$

$$\text{n.} = \frac{\text{v.}}{\text{c.} \times \text{2d.} \times \text{r.}} \qquad \text{2d.} = \frac{\text{v.}}{\text{n.} \times \text{c.} \times \text{r.}}$$

To find the efficiency of incandescent lamps when:

C. = current in amperes.

E. = electromotive force in volts.

$$\text{R.} = \frac{\text{E}}{\text{C}} = \text{resistance of lamp, hot.}$$

C.P. = candlepower of lamp.

W. c.p. = watts per candlepower (a measure of efficiency of lamp). (See p. 115.)

One electrical H.P. = 746 watts.

$$\text{Watts per C.P.} = \frac{\text{C.} \times \text{E.}}{\text{C. P.}}$$

$$\text{Number candles per electric H.P.} = \frac{746}{\text{W.c.p.}}$$

As the efficiency of conversion of good dynamos is 90 per cent., the calculations of candles per electrical H.P. must be multiplied by this factor to give the number of candles per mechanical horse-power.

The weight and resistance per mile of round wire, where d. is the diameter in mils, are:

	Weight.	Resistance at 75°
For copper wire	$\frac{d^2}{62.5}$ lbs.	$\frac{380060}{d^2}$ ohms.
For iron wire	$\frac{d^2}{72}$ lbs.	$\frac{56970}{d^2}$ ohms

To ascertain the sectional area:

Diameter = d.

Sectional area in circular mils = d^2.

Copper wire is 1.14 times the weight of an iron wire of the same size.

A copper wire 334 circular mils in cross-section and 1000 feet in length weighs one pound.

The percentage of conductivity of any wire is found by multiplying the resistance of a pure wire of the same length and weight at the same temperature by 100, and dividing the product by the resistance of the wire as measured.

Unit.	Equivalent Value in Other Units.
1 H. P. =	746 watts. .846 K. W. 33,000 ft.-lbs. per minute. 550 ft.-lbs. per second. 2,545 heat-units per hour. 42.4 heat-units per minute. .707 heat-unit per second. .175 lb. carbon oxidized per hr. 2.64 lbs. water evaporated per hour from and at 212° F.
1 H. P. Hour =	746 K. W. hours. 1,980,000 ft.-lbs. 2,545 heat-units. 273,740 k. g. m. .175 lb. carbon oxidized with perfect efficiency. 2.64 lbs. water evaporated from and at 212° F. 17.00 lbs. water raised from 62° to 212° F.
1 Kilowatt =	1,000 watts. 1.34 H. P. 2,654,200 ft.-lbs. per hour. 44,240 ft.-lbs. per minute. 737.3 ft.-lbs. per second. 3,412 heat-units per hour. 56.9 heat-units per minute. .948 heat-unit per second. .2275 lb. carbon oxidized per hour. 3.53 lbs. water evaporated per hour from and at 212° F.
1 Watt per sq. in. =	8.19 heat units per sq. ft. per minute. 6,371 ft.-lbs. per sq. ft. per minute. .193 H. P. per sq. ft.
1 Kilogram Metre =	7.233 ft.-lbs. .00000365 H. P. hour. .00000272 K. W. hour. .0093 heat-units.
1 lb. Water Evaporated from and at 212° F. =	.283 K. W. hour. .379 H. P. hour. 965.7 heat-units. 103,900 k. g. m. 1,019,000 joules. 751,300 ft.-lbs. .0664 lb. of carbon oxidized.

Unit.	Equivalent Value in Other Units.
1 Heat-unit =	1,055 watt seconds. 778 ft.-lbs. 107.6 .000293 K. W. hour. .000393 H. P. hour. .0000688 lb. carbon oxidized. .001036 lbs. water evaporated from and at 212° F.
I Heat unit per sq. ft. = per min.	.122 watts per sq. in. .0176 K. W. per sq. ft. .0236 H. P. per sq. ft.
1 Watt =	1 joule per second. .00134 H. P. 3,412 heat-units per hour. .7373 ft.-lb. .0035 lb water evaporated per hour. 44.24 ft.-lbs. per minute.
1 K. W. Hour =	1,000 watt hours. 1.34 H. P. hours. 2,654,200 ft.-lbs. 3,600,000 joules. 3,412 heat-units. 367,000 kilogram metres. ,235 lb. carbon oxidized with perfect efficiency. 3.53 lbs water evaporated from and at 212° F. 11.75 lbs. of water raised from 62° to 212° F.
1 Joule =	1 watt second. .000000278 K. W. hour. .102 k. g. m. .0009477 heat-units. .7373 ft.-lb.
1 ft.-lb. =	1.356 joules. .1383 k. g. m. .000000377 K. W. hours. .001285 heat-units. 0000005 H. P. hour.
1 lb. Carbon Oxidized = with Perfect Efficiency.	14,544 heat units. 1.11 lb. anthracite coal ox. 2.5 lbs. dry wood oxidized. 21 cu. ft. illuminating gas. 4.26 K. W. hours. 5.71 H. P. hours. 11,315,000 ft.-lbs. 15 lbs. of water evaporated from and at 212° F.

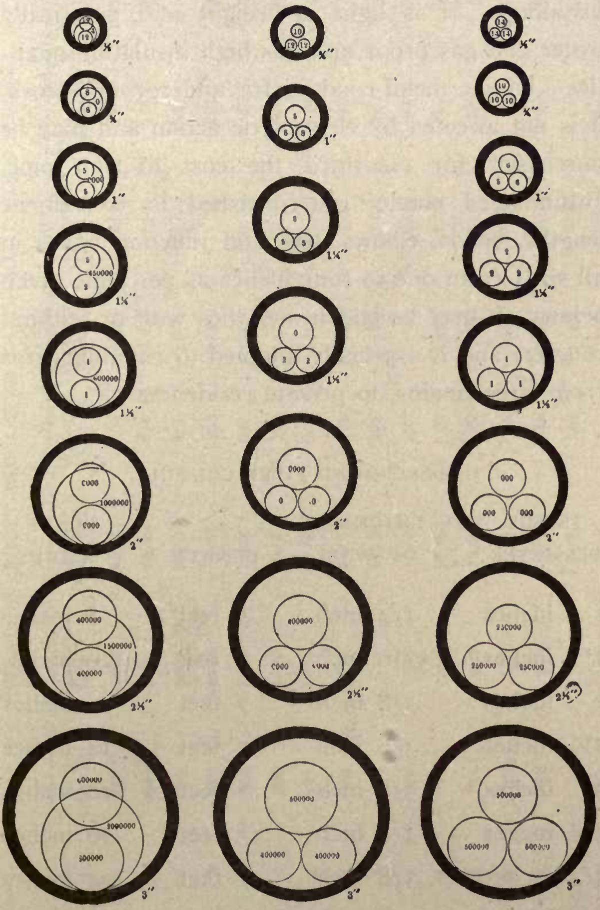
CONDUIT SIZES FOR DIFFERENT SIZE WIRES.

No. B & S	Circular Mills.	Amperes Rubber.	Size of Pipe 1 Wire.	2 Wire.	3 Wire.
18	1,624	3	½	½	½
16	2,583	6	½	½	½
14	4,107	15	½	½	¾
12	6,530	20	½	¾	¾
10	10,380	25	½	¾	1
8	16,510	35	½	1	1
6	26,250	50	¾	1	1¼
5	33,100	55	¾	1¼	1¼
4	41,740	70	¾	1¼	1½
3	52,630	80	¾	1¼	1½
2	66,370	90	¾	1½	2
1	83,690	100	1	1½	2
0	105,500	125	1	2	2
2.0	133,100	150	1	2	2
3.0	167,800	175	1¼	2	2½
4.0	211,600	225	1¼	2	2½
	200,000	200	1¼	2	2½
	250,000	235	1½	2½	2½
	300,000	275	1½	2½	3
	350,000	300	1½	2½	3
	400,000	325	1½	3	3
	450,000	380	2	3	3½
	500,000	400	2	3	3½

In laying out a conduit job, first ascertain the size and number of wires required, then take the sizes of conduit from the above table. One-half inch is usually used for branch conduits and is the smallest size permitted by the National Electrical Code. In running several conduits together, a pull box will be found more economical than elbows for making turns, as one pull box will take the place of several elbows.

CONDUIT AND WIRE DIAGRAM

SHOWING ACTUAL RELATION OF VARIOUS SIZES DOUBLE BRAID RUBBER COVERED WIRE TO CONDUIT.



Underground Conduit: The use of bituminized fibre conduit for all underground work is recommended on account of its simplicity and ease in installing. It is light in weight and practically water and gas proof and has high insulating qualities. Unlike metal conduit, for underground work, it is not affected by electrolytic action and may be purchased for one-third the cost of iron pipe. Bituminized conduit is furnished in convenient lengths, bends, elbows, tees and junction boxes in all sizes from one to four inches as per table given below. It may be laid in trenches with or without concrete and is especially adapted to running wires from street mains, to private residences.

UNDERGROUND FIBRE CONDUIT.

INSIDE DIAMETER	THICKNESS OF WALL	LENGTH	BENDS RADIUS
1 inches	1/4 inch	5 feet	8 inches
1½ inches	5/16 inch	5 feet	10 inches
2 inches	3/8 inch	7 feet	12 inches
2½ inches	3/8 inch	7 feet	14 inches
3 inches	3/8 inch	7 feet	18 inches
3¼ inches	3/8 inch	7 feet	20 inches
3½ inches	3/8 inch	7 feet	24 inches
4 inches	3/8 inch	7 feet	30 inches

"WEATHERPROOF" INSULATED WIRE—SOLID CONDUCTORS.

Size B. & S.	Weatherproof Wire Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.	Slow-Burning Weatherproof Wire Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.	Slow-Burning Wire Wgt. per 1,000 Ft.	Wgt. per Mile.	Diameter Over All.
0000	767	4050	25/32	862	4550	3/4	925	4890	3/4
000	630	3220	47/64	710	3750	45/64	760	4020	45/64
00	502	2650	39/64	562	2970	37/64	600	3170	37/64
0	407	2150	9/16	462	2440	17/32	495	2610	17/32
1	316	1670	1/2	340	1800	15/32	365	1930	15/32
2	260	1370	15/32	280	1480	7/16	320	1690	7/16
3	200	1050	27/64	230	1220	13/32	270	1425	13/32
4	164	865	25/64	190	1000	3/8	220	1160	3/8
5	134	710	11/32	155	820	11/32	190	1000	11/32
6	112	590	5/16	127	670	5/16	160	845	5/16
8	75	395	17/64	85	450	7/64	100	530	17/64
10	53	280	1/4	60	315	1/4	80	420	1/4
12	35	185	7/32	42	220	7/32	55	290	7/32
14	25	130	3/16	80	160	3/16	40	210	3/16
16	14	75	5/32	15	80	5/32	18	95	5/32
18	11	58	1/8	12	63	1/8	14	75	1/8

"WEATHERPROOF INSULATED WIRES—STRANDED CONDUCTORS.

2000000 C.M.	7000	37000	2 1/8	7300	38500	2	7800	41000	2
1750000 C.M.	6200	32750	2	6550	34600	1 7/8	6900	36300	1 7/8
1500000 C.M.	5400	28500	1 7/8	5675	30000	1 3/4	6000	31300	1 3/4
1250000 C.M.	4500	23800	1 3/4	4780	25200	1 11/16	5000	26400	1 11/16
1000000 C.M.	3675	19400	1 21/32	3860	20400	1 39/64	3980	21000	1 39/64
900000 C.M.	3330	17600	1 39/64	3520	18600	1 9/16	3640	19200	1 9/16
800000 C.M.	3000	15800	1 9/16	3180	16800	1 33/64	3280	17300	1 33/64
700000 C.M.	2650	14000	1 15/32	2820	14900	1 27/64	2920	15400	1 27/64
600000 C.M.	2235	11800	1 21/64	2350	12400	1 9/32	2460	13000	1 9/32
500000 C.M.	1900	10000	1 1/4	1990	10500	1 13/64	2080	11000	1 13/64
450000 C.M.	1725	9100	1 3/16	1820	9600	1 9/64	1900	10000	1 9/64
400000 C.M.	1550	8200	1 9/64	1650	8700	1 3/32	1700	9000	1 3/32
350000 C.M.	1345	7100	1	1440	7600	3 1/32	1500	7900	31/32
300000 C.M.	1175	6200	31/32	1270	6700	15/16	1310	6900	15/16
250000 C.M.	985	5200	29/32	1060	5600	7/8	1120	5900	7/8
0000	800	4220	55/64	900	4750	53/64	940	5070	53/64
000	653	3450	51/64	735	3880	49/64	784	4150	49/64
00	522	2760	43/64	583	3080	41/64	625	3300	41/64
0	424	2240	39/64	480	2530	37/64	510	2700	37/64
1	328	1735	35/64	355	1870	33/64	380	2000	33/64
2	270	1425	33/64	290	1540	31/64	335	1770	31/64
3	206	1090	15/32	240	1270	29/64	280	1480	29/64
4	170	900	7/16	195	1030	27/64	230	1220	27/64
5	140	740	3/8	160	845	3/8	195	1030	3/8
6	115	610	11/32	132	695	11/32	165	870	11/32

"RUBBER-COVERED" INSULATED WIRE—SOLID CONDUCTORS.

Size B. & S.	Diam. of Conductors, Mils.	Circular, Mils.	Single Braid		Double Braid	
			Diam. Over All.	Weight Per 1,000 Ft.	Diam. Over All.	Weight Per 1,000 Ft.
0000	460	211600	47/64	809	55/64	832
000	410	167803	11/16	666	13/16	690
00	365	133079	5/8	546	47/64	568
0	325	105524	19/32	453	45/64	476
1	289	83695	33/64	355	5/8	376
2	258	66373	29/64	275	9/16	295
3	230	52634	27/64	227	33/64	245
4	204	41743	25/64	186	15/32	200
5	182	33102	23/64	160	7/16	170
6	162	26250	5/16	128	25/64	135
8	129	16510	17/64	80	11/32	86
10	102	10382	15/64	58	19/64	64
12	81	6530	7/32	43	9/32	48
14	64	4107	13/64	32	1/4	37
16	51	2583	3/16	20	.....	...
18	40	1624	11/64	16	.....	...
19	36	1288	5/32	15	.....	...
20	32	1022	9/64	14	.....	...

"RUBBER-COVERED" INSULATED WIRES—STRANDED CONDUCTORS.

Size B. & S.	Concentric Strands No. Wires	Concentric Strands Diam. Each	Diam. of Conductors, Mils.	Single Braid Diam. Over All	Single Braid Weight Per 1,000 Ft.	Double Braid Diam. Over All	Double Braid Weight Per 1,000 Ft.
2000000 C.M.	91	148	1650	2	7246	2 9/64	7385
1750000 C.M.	91	139	1550	1 29/32	6394	2 3/64	6525
1500000 C.M.	91	128	1430	1 51/64	5539	1 15/16	5658
1250000 C.M.	91	117	1808	1 43/64	4678	1 13/16	4783
1000000 C.M.	61	128	1166	1 1/2	3754	1 5/8	3849
900000 C.M.	61	121	1104	1 7/16	8404	1 9/16	3491
800000 C.M.	61	115	1049	1 3/8	3058	1 1/2	3138
750000 C.M.	61	111	1013	1 11/32	2881	1 15/32	2956
700000 C.M.	61	107	978	1 5/16	2709	1 7/16	2880
650000 C.M.	61	103	943	1 17/64	2534	1 25/64	2600
600000 C.M.	61	99	906	1 1/4	2355	1 3/8	2418
550000 C.M.	61	95	870	1 13/64	2182	1 21/64	2240
500000 C.M.	37	116	821	1 1/8	1959	1 1/4	2010
450000 C.M.	37	110	779	1 3/32	1791	1 7/32	1840
400000 C.M.	37	104	738	1 3/64	1608	1 11/64	1650
350000 C.M.	37	97	688	1	1431	1 1/8	1468
300000 C.M.	37	90	639	15/16	1250	1 1/16	1285
250000 C.M.	37	82	583	7/8	1071	1	1103
0000	19	.105	530	13/16	899	15/16	942
000	19	.094	475	3/4	740	7/8	782
00	19	.083	425	45/64	607	13/16	647
0	19	.074	380	5/8	492	47/64	526
1	19	.066	329	9/16	387	43/64	417
2	19	.059	296	1/2	303	39/64	329
3	7	.086	263	29/64	249	9/16	272
4	7	.077	233	7/16	204	17/32	227
5	7	.068	209	13/32	175	1/2	192
6	7	.061	185	3/8	141	29/64	156

FINE MAGNET WIRE.

No. B. & S. Gauge.	Diameter.	Ohms, Per Pound: Single Cotton.	Ohms, Per Pound: Double Cotton.	Feet, Per Pound: Single Cotton.	Feet, Per Pound: Double Cotton.
20	.0319	3.15	3.02	311	298
21	.0284	4.97	4.72	389	370
22	.0253	7.87	7.44	491	461
23	.0225	12.45	11.7	624	584
24	.0201	19.65	18.25	778	745
25	.0179	30.9	28.45	658	903
26	.0159	48.5	44.3	1188	1118
27	.0142	76.5	68.8	1533	1422
28	.0126	120.	106.5	1903	1759
29	.0112	190.5	164.	2461	2207
30	.0100	294.5	252.	2893	2584
31	.0089	461.	384.5	3483	2768
32	.0079	717.	585.	4414	3737
33	.0070	1115.	880.	5688	4697
34	.0063	1715.	1315.	6400	6168
35	.0056	2640.	1960.	8393	6737
36	.005	4070.	2890.	9846	7877
37	.0044	6180.	4230.	11636	9309
38	.0039	9430.	6150.	13848	10666
39	.0035	14200.	8850.	18286	11907
40	.0031	21300.	12500.	24381	14222

TABLE OF IRON, STEEL AND COPPER WIRE.

Gauge.	Diameter in .001 inch.			Pounds in One Mile.				Feet in One Pound.				Resistance in Ohms Per Mile.			
	Galvanized Iron B. W. G.	Copper B. S.	Copper Old B. W. G.	Galvanized Iron B. W. G.	Galvanized Steel.	Copper B. & S.	Copper Old B. W. G.	Galvanized Iron B. W. G.	Galvanized Steel.	Copper B. & S.	Copper Old B. W. G.	Galvanized Iron B. W. G.	Galvanized Steel B. W. G.	Copper, B. & S., 60° Fah.	Copper, Old B. W. G., 60° Fah.
1	.300	.289	.300	1251		1328	1438	4.22		4	3.7	3.76		.66	.61
2	.284	.258	.284	1121		1069	1289	4.72		5	4.1	4.19		.81	.68
3	.259	.229	.259	932		835	1072	5.65		6.3	4.9	5.04		1.04	.81
4	.238	.204	.238	787		662	905	6.70		8	5.8	5.97		1.31	.96
5	.220	.182	.220	673		526	774	7.87		10	6.8	6.99		1.65	1.13
6	.203	.162	.203	573		417	659	9.17		12.6	8	8.21		2.08	1.32
7	.180	.144	.180	450		330	518	11.25		16	10.2	10.44		2.63	1.65
8	.165	.129	.165	378		262	435	13.89		20	12.1	12.42		3.32	2.
9	.148	.114	.148	305		208	350	17.25		25	15.1	15.44		4.13	2.49
10	.134	.102	.134	250		165	287	21.29		32	18.4	18.83		5.17	3.04
11	.120	.091	.120	200		131	230	27.03		40	22.9	23.48		6.48	3.79
12	.108	.081	.109	165	163	103	190	32.21	32.4	50	27.8	28.46	39.36	8.2	4.59
13	.095	.072	.095	125		82	144	41.65		64	36.6	37.47		10.39	6.04
14	.083	.064	.083	96	98	65	110	45.51	55.6	81	48	49.08	67.88	13.12	7.91
15	.072	.057	.072			51	83			102	63.7	65.23		16.55	10.5
16	.065	.051	.065		55	41	67		96.	126	78.2	80.03	110.70	20.7	12.9
17	.058	.045	.058			32	54			162	98.2	100.50		26.5	16.2
18	.049	.040	.049			26	38			208	137.6	140.80		33.7	22.7
19		.035	.042			20	28			256	187.3			41.5	30.9
20		.032	.035			16	20			323	269.7			52.5	44.5

BREAKING WEIGHTS.

ENGLISH SYSTEM.

Numbers B & S Gauge	Diameter in Mils.	Breaking Weight Hard Drawn Copper. Pounds	Breaking Weight "Phono-Electric." Pounds
0000	460	8310	11460
000	409.6	6580	9140
00	364.8	5226	7400
0	324.9	4558	6300
1	289.3	3746	5250
2	257.6	3129	4180
3	229.4	2480	3360
4	204.3	1967	2700
5	181.9	1559	2080
6	162	1237	1680
7	144.3	980	1350
8	128.5	778	1075
9	114.4	617	850
10	101.9	489	685
11	90.74	388	545
12	80.81	307	420
13	71.96	245	340
14	64.08	193	270
15	57.07	153	220
16	50.82	133	180
17	45.26	97	135
18	40.30	77	107

ELASTIC LIMIT.

Wire.	Numbers B & S Gauge	Diameter in Mills.	Tensile Strength. Pounds per Square Inch.	Elastic Limit. Pounds per Square Inch.
Hard Drawn Copper...	00	364.8	52000	41775
"Phono-Electric"	00	364.8	73500	57860
Hard Drawn Copper...	0	324.9	54000	39645
"Phono-Electric"	0	324.9	76500	55195

Length of Belting for Various Purposes.

$$\text{Open belting: } L = \frac{\pi}{2} S. + 2C. \left(1 + \frac{1 D^2.}{8 C^2.} \right)$$

L = Length of belt.

S = Sum of pulley diameters.

C = Distance between centers of pulleys.

D = Difference of pulley diameters.

π = 3.141592, or, for practical purposes, 3.1416.

For calculating the length of belting approximately, add one-half the circumference of each pulley to twice the distance between centers of the pulleys.

To find the horsepower strength of double leather belting when:

d. = diameter of small pulley in inches.

r. = revolutions of small pulley per minute.

b. = breadth of belting in inches.

H.P. = horsepower to be transmitted.

$$H.P. = \frac{d \times r \times b}{1925}$$

"Double" belting is expected to transmit twice that of "single" belting, and "light double" one and one-half times that of "single."

Strength of wrought iron or steel Shafting.

(Formula as used by Pencoyd Iron Works.)

$$d = \sqrt[3]{\frac{50 \text{ h. p.}}{R}} \text{ for bare shafts, or H. P.} = \frac{Rd^3}{50}$$

$$\text{or } d = \sqrt[3]{\frac{70 \text{ h. p.}}{R.}} \text{ for shafts carrying pulleys, etc.,}$$

$$\text{or H.P.} = \frac{Rd^3}{70}$$

$$l = \sqrt[3]{720\, d^2} \text{ for bare shafts, or } d = \sqrt[2]{\frac{l^3}{720}}$$

$$\text{or } l = \sqrt[3]{140\, d^2} \text{ for shafts carrying pulleys, etc..}$$

$$\text{or } d = \sqrt[2]{\frac{l^3}{140}}$$

H.P. = horse-power transmitted.
d = diameter shaft in inches.
R = revolutions per minute.
l = length between supports in feet.

To find the horse-power of engines:

in which:

H.P. = indicated horse-power.
Ps = travel of piston in feet per minute.
A = area of piston in square inches.
M. E. P. = mean effective pressure in pounds per square inch.
Ip = initial pressure.

and:

$$(a)\ \text{M. E. P.} = \frac{34 \times Ip}{57} \quad \text{at } \tfrac{1}{4} \text{ cut off.}$$

$$(b)\ \text{M. E. P.} = \frac{11 \times Ip}{13} \quad \text{at } \tfrac{1}{2} \text{ cut off.}$$

An application of these formulæ in an appropriate example may be considered in the following **problem:**

It is desired to determine the I. H. P. of an engine whose cylinder is 10 inches in diameter and whose stroke is 12 inches, operating at 300 revolutions per minute, the initial steam pressure being 100 pounds per square inch, cutting off at ½ and ½ stroke, respectively:

$$(a)\ \text{M.E.P.} = \frac{34 \times \text{Ip}}{57} = \frac{34 \times 100}{57} = 59.65 \text{ at } \tfrac{1}{4}$$

cut off.

$$(b)\ \text{M.E.P.} = \frac{11 \times \text{Ip}}{13} = \frac{34 \times 100}{13} = 84.6 \text{ at } \tfrac{1}{2}$$

cut off.

$$\text{A} = \frac{\text{n}}{4} \times \text{diameter}^2 = .7854 \times 10^2 = 78.54 \text{ square}$$

inches.

Ps = .2 feet per revolution and 30 revolutions per minute = 600 feet per minute.

$$\text{I. H. P. at } \tfrac{1}{4} \text{ cut off} = \frac{\text{Ps} \times \text{A} \times \text{M. E. P.}}{33{,}000} =$$

$$\frac{600 \times 78.54 \times 59.65}{33{,}000} = 85.18$$

$$\text{I. H. P. at } \tfrac{1}{2} \text{ cut off} = \frac{\text{Ps} \times \text{A} \times \text{M. E. P.}}{33{,}000} =$$

$$\frac{600 \times 78.54 \times 84.6}{33{,}000} = 120.8$$

To find the horse-power of a pulley:

Multiply the circumference of the pulley in feet by the revolutions per minute, and the product thus obtained by the width of the belt in inches, and divide the result by 600.

This rule is founded on the fact that good, ordinary, single leather belting, with a tension of fifty-five pounds per inch width, will require fifty square feet of belt surface passing over the pulley per minute for one horsepower. Fifty square feet per minute is equal to a belt one inch wide running 600 feet per minute.

To find the speed of a belt, multiply the circumference of the driving pulley in feet by the revolutions per minute.

Belts should always be run with the *grain* side next to the pulley.

Rule for finding size of dynamo driving pulleys.

$$d = \frac{D \times S}{S^1}$$

d = required diameter of dynamo pulley.

D = diameter of engine pulley.

S = number of engine revolutions per minute.

S^1 = required revolutions of armature per minute.

The light cut-off by arc lamp globes is

Ordinary glass	10%
Light ground glass	30%
Heavy ground glass	45 to 50%
Strong opal glass	50 to 60%

INDEX TO CONTENTS.

FORMULAE.

To Find:

TABLES.

CLASSIFIED INDEX

MANUFACTURERS OF OFFICIALLY APPROVED APPARATUS AND SUPPLIES

(See Pages 4 and 5 for Addresses)

Trumbull Elec. Mfg. Co.
Westinghouse Elec. & Mfg. Co.

EXTINGUISHERS, FIRE
Pyrene Manufacturing Co.

FIXTURES, ELECTRIC
Frank Adam Electric Co.
Gas Fixture & Brass Co.
Post-Glover Elec. Co.
Wakefield Brass Co.

FLEXIBLE CORDS
(See Wires)

FUSES, ENCLOSED
Bryant Electric Co.
Chicago Fuse Mfg. Co.
Condit Elecl. Mfg. Co.
Detroit Fuse & Mfg. Co.
D & W Fuse Co.
General Electric Co.
H. W. Johns-Manville Co.
Westinghouse Elec. & Mfg. Co.

FUSES, PLUG TYPE, EDISON
Bryant Electric Co.
Chicago Fuse Mfg. Co.
D & W Fuse Co.
General Electric Co.
H. W. Johns-Manville Co.

FUSES, OPEN LINK
Condit Elecl. Mfg. Co.
Chicago Fuse Mfg. Co.
General Electric Co.
Walker Electric Co.
Westinghouse Elec. & Mfg. Co.

GAUGES, WIRE
Novelty Electric Co.

GENERATORS
(See Motors)

GROUND CLAMPS
Condit Elecl. Mfg. Co.
Fairmount Elec. Mfg. Co.
General Electric Co.
Gillette-Vibber Co.
Hart Mfg. Co.
Novelty Electric Co.
Sprague Elec. Wks. of G. E. Co.

HANGER BOARDS, ARC
Bryant Electric Co.
General Electric Co.

HEATERS, ELECTRIC
(Soldering and Flat Irons)
Cutler-Hammer Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

INSULATING JOINTS
The Macallen Co.
Trumbull Elec. & Mfg. Co.

INSULATORS, POLE LINE
Brookfield Glass Co.
Hemingray Glass Co.

KNOBS & CLEATS, PORCELAI
Cook Pottery Co.
General Electric Co.
Pass & Seymour, Inc.

LAMP CLUSTERS
Luminous Unit Co.

LAMPS, INCANDESCENT
Buckeye Electric Division
General Electric Co.
Lux Mfg. Co.
National Lamp Wks. of G. E. C
Westinghouse Elec. & Mfg. Co.

LAMPS, MERCURY VAPOR
Cooper Hewitt Elec. Co.

LAMP CLUSTERS
General Electric Co.

LIGHTNING ARRESTERS
Electric Service Supplies Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co.

"MEGGERS"
(For Measuring Resistance)
James G. Biddle

METERS, WATT
General Electric Co.
Westinghouse Elec. & Mfg. Co.

MOTORS
Emerson Elec. Mfg. Co.
General Electric Co.
Robbins & Myers Co.
Sprague Elec. Wks. of G. E. Co
Westinghouse Elec. & Mfg. Co.

MOTORS, FAN
(See Motors)

MOULDING, METAL
American Circular Loom Co.
National Metal Molding Co.

PANEL BOARDS
Frank Adam Electric Co.
Bryant Electric Co.
General Electric Co.
Post-Glover Electric Co.
Sprague Elec. Wks. of G. E. Co.
Trumbull Elec. Mfg. Co.
Walker Electric Co.

RECEPTACLES
Bryant Electric Co.
General Electric Co.
Pass & Seymour, Inc.
Trumbull Elec. Mfg. Co.

RHEOSTATS
Cutler-Hammer Mfg. Co.
General Electric Co.
Monitor Controller Co.
Sprague Elec. Wks. of G. E. Co.
Westinghouse Elec. & Mfg. Co.

ROSETTES
Bryant Electric Co.
General Electric Co.
Pass & Seymour, Inc.
Trumbull Elec. Mfg. Co.

SOCKETS, STANDARD
Bryant Electric Co.
General Electric Co.
Pass & Seymour, Inc.

SOCKETS, PORCELAIN
Bryant Electric Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Pass & Seymour, Inc.

SOCKETS, WEATHERPROOF
Bryant Electric Co.
General Electric Co.
H. W. Johns-Manville Co.
Pass & Seymour, Inc.
Trumbull Elec. Mfg. Co.

SOLDERING FLUX
Burnley Battery & Mfg. Co.
M. W. Dunton Co.

SOLDERING IRONS
Vulcan Electric Heating Co.

SWITCHBOARDS
(See Switches, Knife)

SWITCH BOXES
Bryant Electric Co.
Chicago Fuse Mfg. Co.
Cutter Elecl. & Mfg. Co.
Detroit Fuse & Mfg. Co.
General Electric Co.
Hart Mfg. Co.
H. W. Johns-Manville Co.
Machen & Mayer Elecl. Mfg. Co.
Sprague Elec. Wks. of G. E. Co.

SWITCHES, AUTOMATIC, TIME
Reliance Automatic Lighting Co.

SWITCHES, KNIFE
Frank Adam Electric Co.
Bryant Electric Co.
General Electric Co.
Post-Glover Elec. Co.
Trumbull Elec. Mfg. Co.
Walker Electric Co.
Westinghouse Elec. & Mfg. Co.

SWITCHES, OIL BREAK
Condit Elecl. Mfg. Co.
General Electric Co.
Westinghouse Elec. & Mfg. Co

SWITCHES, SNAP
Bryant Electric Co.
Cutler-Hammer Mfg. Co.
General Electric Co.
Pass & Seymour, Inc.
Trumbull Elec. & Mfg. Co.

SWITCHES, FLUSH, PUSH
Bryant Electric Co.
Cutler-Hammer Mfg. Co.
Cutter Elecl. & Mfg. Co.
General Electric Co.
Hart Mfg. Co.
Machen & Mayer Elecl. Mfg. Co.

SWITCHES, FLUSH, ROTARY
Bryant Electric Co.
General Electric Co.
Hart Mfg. Co.

TAPE, FRICTION, INSULATING
M. W. Dunton Co.
The Okonite Co.
Walpole Tire & Rubber Co.

TRANSFORMERS, LIGHT AND POWER
General Electric Co.
Westinghouse Elec. & Mfg. Co.

TRANSFORMERS, BELL RINGING
General Electric Co.
Westinghouse Elec. & Mfg. Co.

VEHICLES, ELECTRIC
General Vehicle Co., Inc.

WIRE, BARE, COPPER
Bridgeport Brass Co.
Phillips Ins. Wire Co.
John A. Roebling's Sons Co.

WIRE, RUBBER COVERED
American Electrical Works
American Steel & Wire Co.
Atlantic Ins. Wire & Cable Co.
Bishop Gutta-Percha Co.
Electric Cable Co.
General Electric Co.
Habirshaw Wire Co.
Indiana Rubber & Ins. Wire Co.
Kerite Ins. Wire & Cable Co.
Lowell Ins. Wire Co.
National India Rubber Co.
The Okonite Co.
Phillips Ins. Wire Co.
John A. Roebling's Sons Co.
Rome Wire Co.
Simplex Wire & Cable Co.
Standard Underground Cable Co.

WIRE, FLEXIBLE CORD
(See Wire, Rubber Covered)

WIRE, SLOW-BURNING
American Electrical Works
American Steel & Wire Co.
Chicago Ins. Wire Co.

General Electric Co.
Phillips Ins. Wire Co.
John A. Roebling's Sons Co.
Standard Underground Cable Co.

WIRE, SLOW-BURNING WEATHERPROOF
Chicago Ins. Wire Co.
General Electric Co.

WIRE, WEATHERPROOF
American Electrical Works
American Steel & Wire Co.
Chicago Ins. Wire Co.
General Electric Co.
National India Rubber Co.
Phillips Ins. Wire Co.
John A. Roebling's Sons Co.
Simplex Wire & Cable Co.
Standard Underground Cable Co.

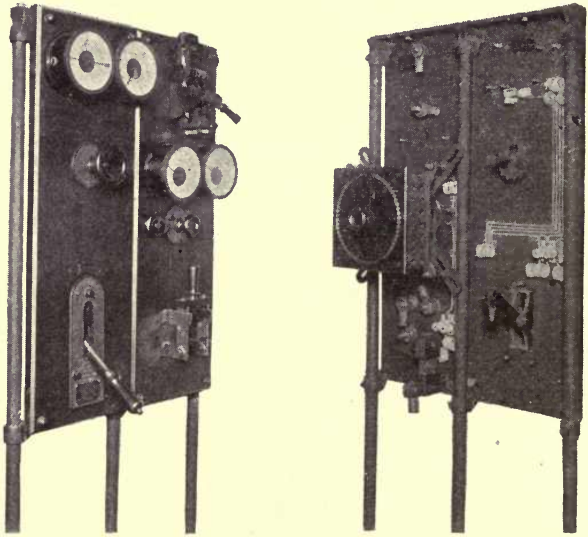
WIRE, "PHONO-ELECTRIC"
Bridgeport Brass Co.

WIRE, RESISTANCE
Driver-Harris Wire Co.

List of Advertisers of Standard Apparatus and Supplies

Only Apparatus and Supplies that are officially approved, or permitted to be used, by the National Board of Fire Underwriters will be accepted in the following pages.

Westinghouse Switchboards



THE use of Westinghouse 7-inch Meters permits the panels of this board to be only 16-inches wide.

The wiring at rear of board is complete. When installing it is only necessary to connect the cables to the terminals provided, and everything is ready for immediate operation.

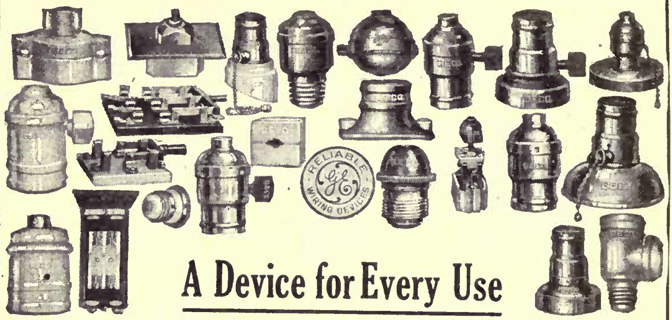
The panels illustrated control a motor-generator set consisting of a 2200 volt Westinghouse synchronous Motor and a 275 volt Westinghouse Direct-Current Generator for mining service.

These boards can be shipped from stock in all usual capacities.

Westinghouse Electric & Mfg. Co.

Sales Offices in All Large Cities

East Pittsburgh Pennsylvania



A Device for Every Use

A few devices illustrating the great variety of G-E wiring supplies are shown in the above group. A complete stock of G-E reliable wiring devices includes every device for use in making installations or extending lighting or power lines in factories, stores, restaurants, places of amusement or homes. In fact, all that is required by the up-to-date electrical contractor will be found in a G-E assortment.

The careful construction of G-E Wiring Supplies insures absolute reliability. This careful construction, together with excellence of design and quality of material, result in a completed product fulfilling all requirements of the National Board of Fire Underwriters for electric wiring.

Electrical contractors and electricians should specify G-E material for all electrical work under their direction. The large G-E assortment meets every wiring need, making standardization easy and insuring the highest possible quality throughout, coupled with permanent satisfaction.

G-E Wiring Devices are for sale by all leading jobbers of electrical material.

General Electric Company

Largest Electrical Manufacturers in the World

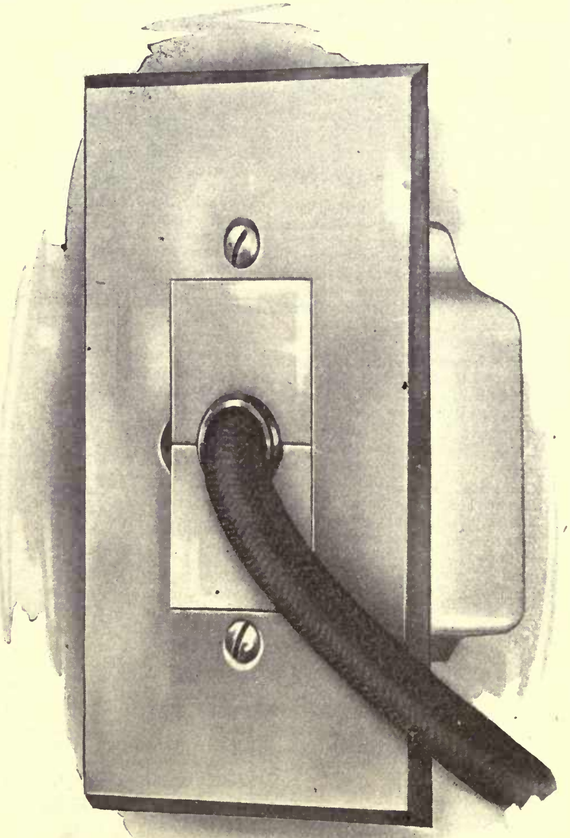
General Office: Schenectady, N. Y.

ADDRESS NEAREST OFFICE

Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va.
Charlotte, N. C.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, Ohio.
Cleveland, Ohio
Columbus, Ohio
Dayton, Ohio
Denver, Colo.
Des Moines, Ia.
Detroit, Mich.
(Office of Agent)
Duluth, Minn.
Elmira, N. Y.
Erie, Pa.
Fort Wayne, Ind.
Indianapolis, Ind.
Jacksonville, Fla.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Los Angeles, Cal.
Louisville, Ky.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Ct.
New Orleans, La.
New York, N. Y.
Niagara Falls, N. Y.
Omaha, Neb.
Philadelphia, Pa.
Pittsburg, Pa.
Portland, Ore.
Providence, R. I.
Richmond, Va.
Rochester, N. Y.
San Francisco, Cal.
Salt Lake City, Utah
St. Louis, Mo.
Schenectady, N. Y.
Seattle, Wash.
Spokane, Wash.
Springfield, Mass.
Syracuse, N. Y.
Toledo, Ohio
Washington, D. C.
Youngstown, Ohio

For Texas, Oklahoma and Arizona business refer to Southwest General Electric Company (formerly Hobson Electric Co.), Dallas, El Paso, Houston, and Oklahoma City. For Canadian business refer to Canadian General Electric Company, Ltd., Toronto, Ont. 4524

MEMBER THE SOCIETY FOR ELECTRICAL DEVELOPMENT, INC.—"DO IT ELECTRICALLY"



MACALLEN

Canopy Insulators

Patented July 13, 1897

Regularly inspected and labeled under the supervision of the Underwriters' Laboratories, Inc., under the direction of the National Board of Fire Underwriters.

They are designed to go between the canopy and the wall or ceiling, where combination or straight electric fixtures are installed in buildings that are constructed with metallic lathing, or where there are metal ceilings or walls used.

They are made of a special compound that is thoroughly waterproof, strong, durable, and of the highest insulating qualities.

We manufacture these insulators to fit all standard sizes of canopies.

TRADE
MACALLEN
MARK

The Macallen Company

Macallen & Foundry Streets

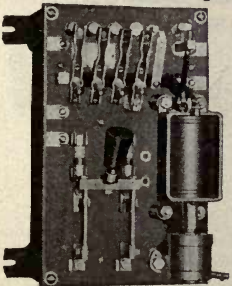
Boston, Mass.

Catalogues and Price Lists Furnished Upon Application

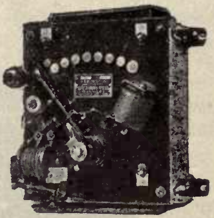
CUTLER-HAMMER

MOTOR CONTROLLERS

Hand Operated and Automatic Types



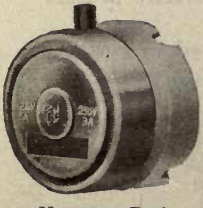
Automatic Starter.



Hand Operated Type Motor Starter with No-Voltage and Overload Release.

Cutler-Hammer Starters and Controllers are made for both direct and alternating current motors. When installing motors tell us what you wish to accomplish and we will send bulletin describing just the apparatus you need.

PUSH BUTTON SPECIALTIES



No. 7109 Push Button Snap Switch

New No. 7500 Brass Shell Push Button Socket

No. 7007 "Acorn" Brass Shell Pendent

The C-H line of specialties includes Porcelain and Brass Shell Pendent Switches, Sockets, Surface Switches, Flash Switches, Fixture Canopy and Candelabra Switches. Door Switches, besides a complete line of Attachment Plugs and Attachment Plug Receptacles.

Ask for Bulletin 8650.

THE CUTLER-HAMMER MFG. CO., Milwaukee

Largest Manufacturers of Electric Controlling Devices in the World

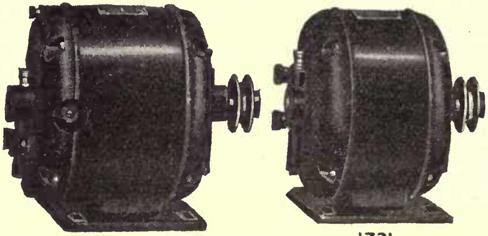
NEW YORK	BOSTON	PITTSBURGH
Hudson Terminal	Columbian Life Bldg.	Farmers' Bank Bldg.
CHICAGO	PHILADELPHIA	CLEVELAND
Peoples Gas Bldg.	1201 Chestnut St.	Schofield Bldg.

PACIFIC COAST AGENTS: H. B. Squires, 579 Howard St., San Francisco, and W. B. Palmer, 416 East Third St., Los Angeles.

Emerson Small Motors

1/30 to 1/2 hp.

For Alternating and Direct Currents


1721

Clutchless Induction Motors
Clutch Type Induction Motors
Enclosed Direct Current Motors
Ventilated Direct Current Motors

A hundred types regularly carried in stock at St. Louis and New York

Special Types developed for any purpose where quantities are required

Write for Printed Matter

The Emerson Electric Mfg. Co.

2032 Washington Ave., St. Louis Mo.
50 Church St., New York City

-:- ***Makers of Emerson Fans*** -:-


KERITE
AN INVESTMENT
Whether the wire or cable be large or small, for high or low tension, the most durable, efficient and permanent insulation known is KERITE
KERITE INSULATED WIRE & CABLE COMPANY
NEW YORK
CHICAGO

Roebling Magnet Wire

is carefully drawn and annealed to produce a soft wire with a minimum variation in gauge, and is covered with a smooth and uniform insulation.

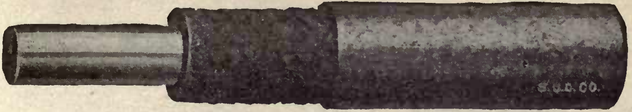
The best metals obtainable and an experience of many years in wire manufacture are combined in the production of this and other Roebling wires which include rubber covered wire, weatherproof wire, lamp cord and all other wires used for electrical purposes.

John A. Roebling's Sons' Co.

TRENTON, N. J.

Agencies and Branches

New York	**Chicago**	**Cleveland**	**Philadelphia**
Pittsburgh	**Atlanta**	**Seattle**	**Los Angeles**
	San Francisco	**Portland, Ore.**	



Rubber Covered : Lamp Cords

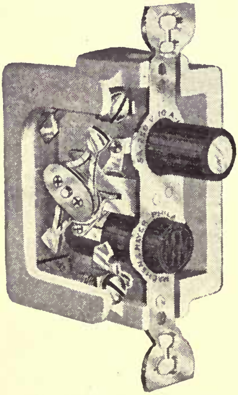
Automobile Cable

Show Window Cords : Telephone Wire

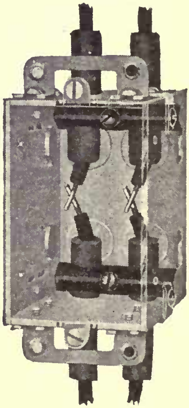
Lowell Insulated Wire Co.

LOWELL, MASS.

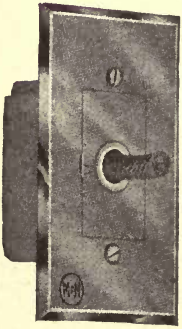
Economy and Reliability

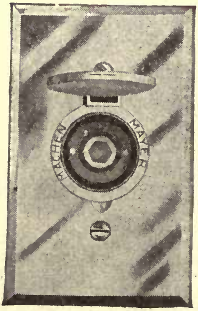


M & M Shallowest Switch
1 7/16" deep



M & M Sectional Wall
Box Equipped with Loom
Clamps 2", 2 1/2" or 3"
deep





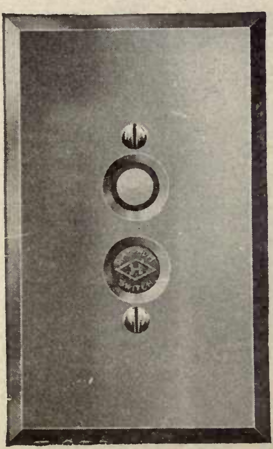
Catalog and Discount Sheet on request

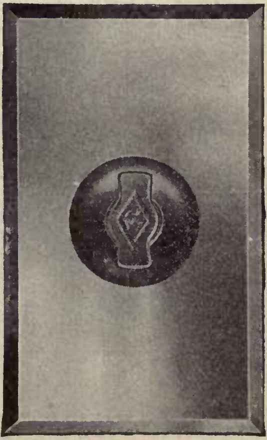
Machen & Mayer Electrical Mfg. Co.

PHILADELPHIA, PA.

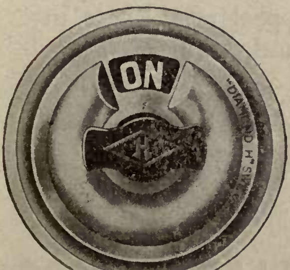
"Diamond H" Switches

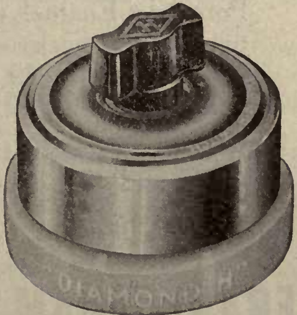
AND FLUSH RECEPTACLES





PUSH BUTTON SWITCHES
ROTARY FLUSH SWITCHES
Rotary Surface Switches
Remote Control Switches



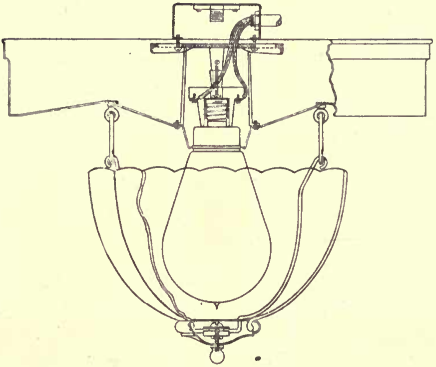


HART MFG. CO., Hartford, Conn.

New York Boston Chicago Pittsburgh Denver Toronto

REFLECTOLYTE

The Unit of Quality and Efficiency



Type P. F.

Porcelain Enamel upper reflector. Will not crack, check or peel off. Made in three sizes, 16, 20 and 24 inch. Plain and ornamental, with one or three chains.

A reflector with the qualities of Opal Glass and the strength of steel.

Write for Catalog No. 26.

FRANK ADAM ELECTRIC CO.

St Louis, Mo., U. S. A.

PIGNOLET INSTRUMENTS

ACCURATE

COMPACT

INEXPENSIVE

Voltmeters, Ammeters and Volt-Ammeters

PORTABLE AND SWITCHBOARD TYPES FOR ALTERNATING AND DIRECT CURRENT.

OUR NEW MODEL P.

The handiest Direct and Alternating Current Portable Meter made; 6″ long, 5″ wide, 3″ deep; weight less than 3 lbs.

We also make several styles of Pocket Meters; 4½″ long, 3¼″ wide, 1¼″ deep, with an extra long scale permitting close readings.

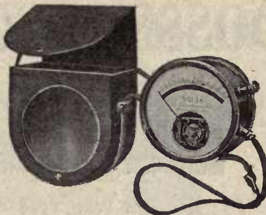
Send for complete Catalog and Directions for Testing.

L. M. PIGNOLET

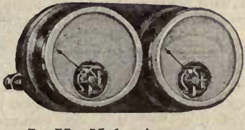
Cor. Cortlandt and Washington Streets

NEW YORK, N. Y.

2½" Type



Portable Type



I. U. Volt Ammeter

A distinguishing, we might almost say exclusive feature of the

HOYT *Line of*

Ammeters and Voltmeters

is their extreme flexibility adapting them to practically every use required in modern practice.

Ask for Bulletin SW

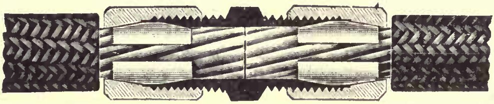
Hoyt Electrical Instrument Works

PENACOOK, N. H.

6" Type

Pocket Ammeter

DOSSERT CONNECTORS

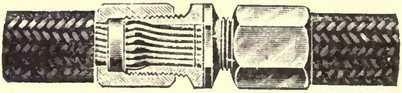


2-Way Type A Showing Details.

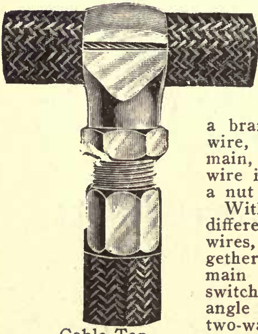
Dossert Connectors eliminate entirely the use of solder in making electrical connections and splices, and are approved for use without solder by the National Board of Fire Underwriters for all classes of wiring.

By their use much labor is saved and splices obtained that will withstand any overload. Many careful tests show that a splice made by means of a Dossert Connector will not heat as much as the cable which it connects when the cable is heavily overloaded.

Type A Connectors are for use on cables, stranded, or solid wires, rods and tubing. They are simple and effective, and by their use splices can be quickly made in conductors of any size. Type A Connectors, however, should not be used on a cable that is to be subjected to heavy tensile strains.



Part Cross-sectional View of Type B 2-Way



Cable Tap

Type B Connectors are for use on stranded wires or cables only, and are designed to make a joint which will withstand heavy tensile strains. They are not made for wires smaller than No. 0.

The Cable Tap is used to connect a branch wire, rod, or bleeder, to a main wire, rod or feeder. It does not splice the main, but simply clamps on to it. Branch wire is connected to cable tap by means of a nut and sleeve as shown in Type A cut.

With Dossert devices any combination of different sizes of cables, stranded and solid wires, rods and tubing can be connected together. The cable tap will tap from any size main to any size branch. Terminal and switchboard lugs, front or back connected; angle and swivel lugs. Insulated connectors; two-ways, three-ways, equalizers, cable anchors, reducers, elbows, Y's, service box lugs and plugs, grounding devices and stud connectors for threaded rods and flat strips or locks.

Send for Tenth Year Catalogue.

Dossert & Company

H. B. LOGAN, President

242 West 41st Street **New York, N. Y.**

TRADE **Wireduct** MARK

NON-METALLIC FLEXIBLE CONDUIT

An Excellent Tubing

TRADE **Wireduct** MARK

is scientifically constructed

¶ The inner tube is of closely woven smooth canvas.

¶ The frame-work consists of spirally wound resilient fibre.

¶ Highest quality of material and insulating compounds.

¶ No irregularities—no obstructions.

¶ Tough and strong, yet flexible.

¶ Smooth and firm inside surface—cuts clean and fishes free.

¶ The size of the interior diameter remains equal and circular throughout the runs, and there is no splitting or pulling apart.

The American Conduit Manufacturing Co.

Pittsburgh, Pa.

"Order by Name"

ALPHADUCT

Meets with instant approval of Architects, Engineers, Contractors and Inspectors.

Send for catalogue.

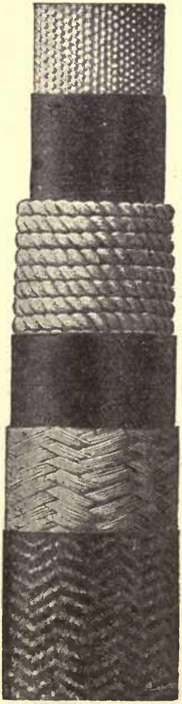
ALPHADUCT FLEXIBLE CONDUIT TRADE MARK FOR ELECTRIC WIRES

Combines perfect flexibility of conduit with strength and solidity of wall.

Easiest to "Fish."

Try it and prove it.

THE HIGHEST ACHIEVEMENT IN THE ART OF INTERIOR CONDUIT CONSTRUCTION



← Inner lining of heavy canvas.

← Water-proof coating.

← Hard fibre cord.

← All intersects filled with special compound.

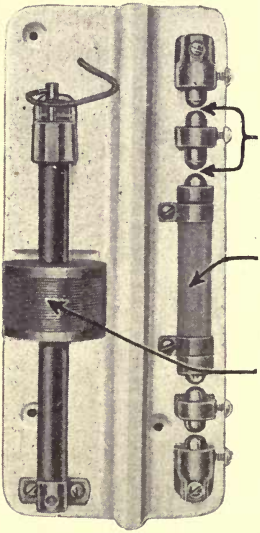
← Outer jacket.

← Outer coating, protection against dampness and abrasion.

→ Finished Conduit.

ALPHADUCT CO., 136 CATOR AVE., JERSEY CITY, N. J.

Safety from Lightning-
Your Price



Small Air Gaps will Give You Protection.

Low Series Resistance will Eliminate Surges, Low Voltages, Winking Lights on Your Circuits.

The Circuit Breaker will Eliminate Grounds and Short-Circuits on Your Lines.

The circuit breaker used in combination with a small air gap and a low series resistance has given

Garton-Daniels Lightning Arresters

their well known characteristics of efficiency and durability.

The air gaps mean protection to your electrical apparatus, because they arc over and discharge potentials but slightly higher than normal.

The low series resistance will eliminate surges, winking lights and other voltage disturbances on your circuits, because it limits the flow of line current, following the lightning discharge to ground to a moderate value—about 10 amperes.

The circuit breaker will eliminate grounds and short-circuits on your lines, because it always positively and unfailingly cuts off this flow of line current to ground.

You can get **complete** lightning protection only from an arrester **combining** these three essential functions.

An installation of Garton-Daniels is **your** only price **for Safety.** Write for catalog.

Electric Service Supplies Co.

Railway Material and Electrical Supplies

PHILADELPHIA, 17th and Cambria Sts.
NEW YORK, Hudson Terminal.
CHICAGO, 417 So. Dearborn St.

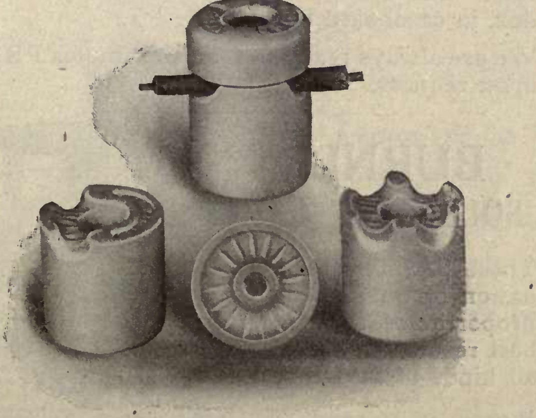
The Cook Wedge Split Insulator

One or Two GROOVE for 10, 12, 14 Wire

Makes Standard Wiring Easy

Made of the Best Hard White Porcelain. No Burrs or Rough Edges to Cut Insulation, but Firmly Grips the Wire when Screwed in Place—The Cap Needs no Centering. Once Used Never Replaced.

Trial Orders Packed 500 in a Box



Protected by U. S. Patents.

Ask Your Jobber or Write Us for Samples and Prices.

COOK POTTERY CO.

Trenton, N. J.

SOLE MANUFACTURERS

BURNLEY
SOLDERING PASTE

Non-Corrosive
Self-Adhesive
Free of Acids
Economical

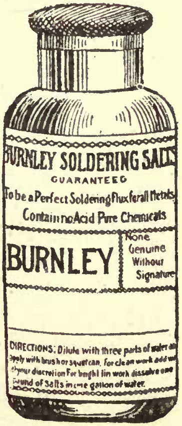
Patented.

Especially adapted for all kinds of Electrical Work.

Put up in 2-oz., 4-oz., ½-, 1-, 5-, 10- and 50-lb. tins. The 2-oz. and 4-oz. sizes are packed 3 doz. in cardboard boxes.

We are always ready to furnish samples FREE upon request.

BURNLEY
SOLDERING SALTS



These SALTS are a combination of pure chemicals so proportioned as to give the best results, as a FLUX, for all kinds of SOLDERING.

Put up in ½- and 1-lb. bottles, also ½- and 1-lb. friction top cans.

Ask for prices.

BURNLEY PASTE AND SALTS

Manufactured and put up by

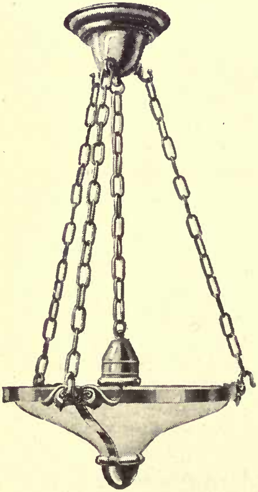
THE BURNLEY BATTERY & MFG. CO.

North East, Pa., U. S. A.

Chas. E. Chapin Co.
201 Fulton St.,
New York City, Agent.

Wakefield Standard Universal Lighting Fixtures

In Wakefield fixtures are combined two characteristics—quality and substantial attractiveness of design. In every Wakefield design you get a fixture built for service first, then built in a design that will wear well; no extremes that quickly come in style and as quickly go out again.



The characteristic of quality is a broad one. It means first, good heavy gauge Brass material throughout. It means second, accurate mechanical construction. It means third, that troubles in handling have been anticipated and Wakefield Fixtures made with more special features to make them easier to wire, easier to put together, easier to install, easier to carry in stock, than the ordinary lines.

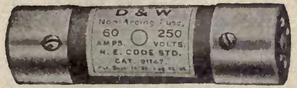
It means service — First, Last and Always. When you buy Wakefield Fixtures you buy the experience of practical people to give you something that you can make just a little more money on than the average and at the same time you can give your customer a satisfactory article.

Whether you buy an attractive shower or an efficient "Mellowlite" Semi Indirect Fixture, you get some feature that means more profit for you in time saved, reputation saved and fixtures more easily sold.

Send for complete catalog of electric designs.

The F. W. Wakefield Brass Company

Vermilion, Ohio

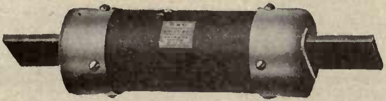


Every Blown Fuse Is An Expense

Every fuse that blows *under its rated capacity* is an *unwarranted* expense.

Many do not analyze the causes that add dollars to their fuse bills.

Defective interior construction, weak joints and imperfect alignment of blades cost fuse consumers hundreds of dollars a year.



Consider These Points In "D & W" Construction

The links are scientifically designed.

Every joint is *riveted* as well as soldered. They won't let go.

The blades are properly aligned. Excessive heating is eliminated.

All metal parts are ample and are securely fastened to the tube.

"D & W" knife blade fuses may be refilled by the factory at an approximate saving of 63%.

They are approved by the National Board of Fire Underwriters.

SPECIFY "D & W" AND GET MORE FUSE VALUE

D & W FUSE COMPANY

Providence, R. I.

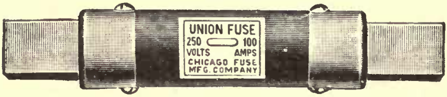
Whether the Job

Be Large or Small

It will pay to use

"UNION"

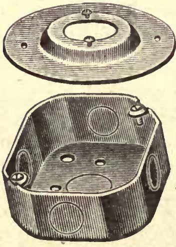
Fuse and Box Material



A Complete Line of Open and Enclosed Fuses, Cut-Out Blocks, Fittings, etc., for All Voltages.

All "Union" Material is made in accordance with the requirements of the National Board of Fire Underwriters.

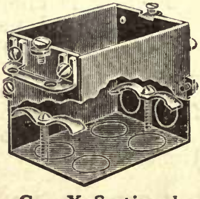
"Union" Fuses, above 60 amperes, may be reloaded at our Factory at a large saving to the user, and are approved.



No. 106—O Box and No. 106—D Cover

Outlet Boxes and Covers to accommodate all regular wiring devices.

Switch Boxes that can be easily taken apart and rebuilt into gangs by the use of spacers. The Standard Line. Pat. Apr. 2, 1907; Mar. 1, 1910; Feb. 13, 1912.



Gem X, Sectional Switch Box

Write for Fuse Catalog No. 26 and Box Catalog No. 27.

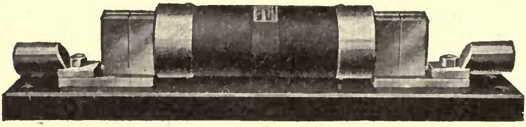
CHICAGO FUSE MFG. CO.

CHICAGO NEW YORK

"Shawmut" Fuses

Exclusive Features
- Black Tube
- Copper Ends
- Ampere Capacity Stamped on Ferrule
- 100% Efficiency Indicator

"Shawmut" Bases



All current carrying parts copper.

Lugs flush with edge of slate.

Clips have ample carrying capacity and being in perfect alignment afford maximum contact.

Condit Electrical Mfg. Co.

Boston, Mass.

W. S. Brown Elec. Co.,
3 W. 29th St., New York City

F. V. L. Smith,
1206 Empire Bldg., Atlanta, Ga.

Hendrie & Bolthoff Mfg. & Supply Co.,
1627 17th St., Denver, Colo.

T. G. Grier Co.,
318 W. Washington St., Chicago, Ill.

Weiss-Bosley Co.,
1403 Chestnut St., St. Louis, Mo.

Holabird-Reynolds Co.,
523-525 Mission St., San Francisco, Calif.

H. G. Behneman,
617 4th Ave., Seattle, Wash.

THE NEW GEE VEE SERVICE CAP

			Price each
½-inch	Cat. No.	6012	$ .45
¾-inch	" "	6034	.60
1-inch	" "	6001	.90

All packed ten in a box.

WRITE FOR DISCOUNTS

THE GILLETTE-VIBBER CO.
TRADE MARK
NEW LONDON, CONNECTICUT.

SIZE MARKED ON EVERY CAP.

SCREWS DO NOT HAVE TO BE TAKEN OUT TO REMOVE COVER BURRED OVER TO PREVENT FALLING OUT.

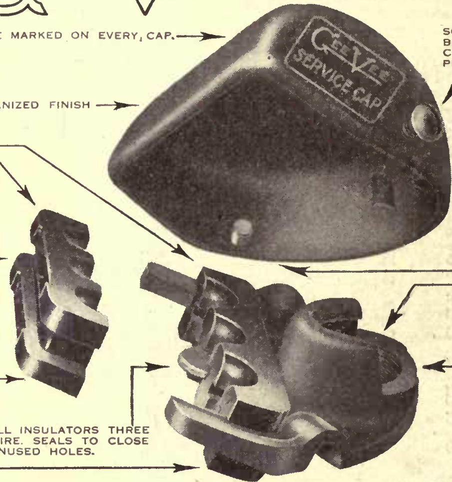
GALVANIZED FINISH

INSULATORS MADE OF MOULDED MATERIAL NO BREAKAGE LIKE PORCELAIN.

GROOVES HOLD INSULATORS IN PLACE NO SCREWS TO BOTHER WITH

INSULATORS IN TWO PARTS SAVES THREADING WIRES THRU HOLES.

ALL INSULATORS THREE WIRE. SEALS TO CLOSE UNUSED HOLES.



THREADED TO COMPLY WITH THE CODE.

WHEN THIS SECTION IS CUT OUT WITH A HACK SAW THE CAP CAN BE APPLIED TO A CONDUIT AFTER THE WIRES ARE CONNECTED WITHOUT DISCONNECTING THEM.

SOME POINTS NOT ILLUSTRATED.

- PACKED IN STRAWBOARD BOXES.
- LOW IN PRICE.
- LARGE STOCK.
- IMMEDIATE SHIPMENTS.
- APPROVED

NOKORODE SOLDERING PASTE

Made with more care than nine-tenths of the druggists compound a doctor's prescription.

Every particle contains all the elements of the flux.

Used exclusively by

U. S. Gov't on the telephone circuits of the Panama Canal

90% of the Electrical Trade of New York and New England and for eleven years by The N.E.Tel.&Tel.Co.

PRICE LIST

2 oz. Cans, less than case lots - -	**$0.25 each.**
2 oz. " 3 dozen (one case) -	**2.00 doz.**
1 lb. " 1-2 " (one case) - -	**1.00 lb.**
10 " " - - - - - -	**1.00 lb.**
25 lb. and 50 lb. Cans - - - -	**.90 lb.**

DISCOUNT IN CASE LOTS 50 PER CENT.
Discount in less than Case Lots, 40 per cent.

OUR PRODUCTS

Uncoated Armature Tapes
Sleevings
Hose
Friction Tapes
Red Rope Paper
Press Boards
Rubber Gloves

THE M. W. DUNTON CO.

PROVIDENCE, 150-152 NIAGARA STREET R. I.